# SIZE-SCALING OF IMAGES IN
# THE BLIND AND SIGHTED

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## PREFACE

It is consistently concluded that the early blind have "no" visual imagery. The present study reexamines this issue. Is it correct to say the early blind have "no" visual imagery, or might another conclusion better fit the data? Possibly the early blind in fact have visual imagery, but only in a "limited" sense. In order to investigate this issue, one specific aspect of imagery ability of the early blind is looked at. Specifically, how proficient are the early blind in comparison to sighted controls in the process of shrinking and enlarging images.

I would like to thank my Committee Chairman, Dr. Robert Weber. Over the years I have found Dr. Weber to be highly knowledgeable, with a vast array of ingenious ideas. I also appreciate the great deal of help I received from my other Committee members: Dr. Ken Sandvold; Dr. Bill Jaynes; and Dr. Brent Snow. It is personally gratifying to work with such reputable individuals.

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## IMAGERY WITHOUT VISUAL PERCEPTION

A distinction has long been established between the visual imagery ability of the early blind and the visual imagery ability of the late blind. "Early blind" refers to individuals who lost their sight near birth and "late blind" refers to individuals who lost their sight later in life. For instance, Jastrow (1888) found that the early blind reported their dreams as being devoid of visual imagery content, while the late blind reported having visual imagery contents in their dreams. From these findings, Jastrow concluded that the early blind have no developed visual imagery, while the late blind have a developed visual imagery system. Subsequent introspective and self-report studies have reached the same conclusion (Fernald, 1913; Johnson, 1980; Schlaegel, 1953; Singer and Streiner, 1966). (See Appendix B for a detailed discussion of these studies.)

Further studies have found the early blind perform poorly, relative to the late blind and sighted, on a variety of tasks involving spatial orientation (Drever, 1955; O'Connor & Hermline, 1975; Sylvester, 1913; Worchel, 1951), mental rotation (Carpenter & Eisenberg, 1978; Marmor & Zaback, 1976), cognitive mapping (Casey, 1978; Cleaves & Royal, 1979; Herman, Chatman, & Roth, 1980), and other imagery related tasks (Jonides, Kahn & Rozin, 1975; Marmor, 1977). (See Appendix B for a detailed discussion of these studies.) The early blind's poor performance on such tasks is generally attributed to a visual imagery deficit: namely, that the early blind have no visual imagery in which to efficiently complete such tasks. It is further presumed that the late blind have visual imagery, being generally more efficient on such tasks.

Thus, a variety of research rests on the belief that the early blind have no visual imagery. This "No Visual Imagery Hypothesis" encompasses a particular line of reasoning. This hypothesis assumes visual perception experiences are required before visual imagery can develop. The logic then, is that the early blind have no visual imagery, having no visual perception experiences.

However, the logic behind the No Visual Imagery Hypothesis may not be entirely correct. To understand the possible error in such logic it is helpful to conceptualize a visual image as a composite of certain qualities: color; brightness; clarity; form; texture; and sometimes movement. The logic behind the No Visual Imagery Hypothesis assumes all these qualities within a visual image are derived initially through visual perception experiences. Possibly some of these qualities such as color, clarity and depth are dependent on some initial visualization. However, form, texture, and movement within a visual image are less likely to depend on visualization, but may be derived initially through spatial or tactual perception and then incorporated into a visual image. In short, it seems accurate to say certain qualities of a visual image may necessarily be dependent on some initial visual perception while other qualitities of a visual image may be derived through other than visual perceptual sources. This is quite different than assuming that visual imagery is solely developed out of visual perception, as does the No Visual Imagery Hypothesis.

This brings up an alternative view point, the "Limited Visual Imagery Hypothesis". This Limited Visual Imagery Hypothesis holds that the early blind have some "limited" visual imagery, derived through non-visual perception experiences. This limited visual imagery would probably not include color, brightness, etc. which seem inherent to visual perception. It would however probably include form and movement, qualities which may not be exclusively dependent on visual perception. As such, this limited imagery may seem so limited as not to be likened to visual imagery. However, such a system in the early blind, if it exists, probably would operate through the visual imagery mechanisms, which would have otherwise produced color, brightness, etc., given visual perception had developed. In this sense such a Limited Visual Imagery system is visual in character.

As with any newly formed hypothesis, the Limited Visual Imagery Hypothesis must be consistent with the existing literature. Take, for example, the above citied studies which found the early blind performed poorly in spatial orientation, cognitive mapping, mental rotation, and other imagery related tasks. These studies attributed the early blind's poor performance to their having no visual imagery. Yet the Limited Visual Imagery Hypothesis is also consistent with these results, given a different line of reasoning. The reasoning is that such results reflect the short-comings of the limited visual imagery of the early blind, rather than concluding the early blind have no visual imagery. In fact, the No Visual Imagery Hypothesis must explain just how the early blind were able to perform such tasks at whatever level without using visual imagery.

Even more direct support for the Limited Visual Imagery Hypothesis is provided by other studies (Drever, 1955; Ewart & Carp, 1963; O'Connor & Hermline, 1975; Worchel, 1951). These studies found no difference between the early blind and sighted on particular imagery tasks, involving the detection and manipulation of imagined forms. The traditional or No Visual Imagery Hypothesis assumed such results meant the tasks themselves did not involve visual imagery, or else the early blind would have performed poorly. Yet, in reviewing the tasks it is difficult to imagine that such tasks did not involve at least some visual imagery. In keeping with this supposition, the reasoning behind the Limited Visual Imagery Hypothesis is to assume such tasks actually involve visual imagery, and that the limited visual imagery of the early blind is fully capable in such situations. This capacity of the Limited Visual

Imagery system is not surprising since such form discrimination tasks stress the salient characteristics postulated to exist within the early blind's limited visual imagery, i.e., form and movement abilities. This would not be the case if such tasks involved color, brightness, depth, etc. (not postulated as part of the Limited Visual Imagery of the early blind), in which case the early blind would be at a disadvantage.

There are then, two potential hypotheses, the No Visual Imagery and Limited Visual Imagery hypotheses which fit the data. Both these hypotheses suggest that the lack of visual perception affects visual imagery to some degree. Research does indicate that perception and imagery of a given modality are linked (Bowers, 1972; Bowers & Glass, 1976; Podgorny & Shepard, 1978: Segal & Fusella, 1970). But the two hypotheses differ as to how much effect visual perception has on visual imagery development. The No Visual Imagery Hypothesis assumes that initial visual imagery is solely developed or determined through visual perception while the Limited Visual Imagery Hypothesis assumes that initially, visual imagery is not exclusively developed or determined through visual perception.

The issue concerning these two hypotheses becomes more complex with the necessary inclusion of spatial imagery into the conceptualization. Many researchers suggest that visual imagery involves a large spatial component, visual imagery being more than a pictorial representation of the world but a spatial representation as well (Baddeley, 1976; Brooks, 1968; Byrne, 1974). Other researchers have suggested that visual imagery plays a large role in spatial imagery (Attneave & Benson, 1969; Huttenlocher & Presson, 1973). Taken together such conclusions are persuasive evidence that visual and spatial imagery are not distinct entities, but form a composite system. As such the hypothesis stated above might better be labeled the No Visual/Limited Spatial Imagery Hypothesis and the Limited Visual/Limited Spatial Imagery Hypothesis, signifying the inclusion of the spatial component.

At any rate, the early blind do seem to have a visual/spatial deficit. The extent and origin of this deficit may not be as clear as the No Visual Imagery hypothesis implies, relying as it does on a possible flawed assumption, that visual imagery developes exclusively through visual perception. It seems better to experimentally explain the origin of such deficits in the early blind rather than rely on such an assumption. One study which did find differences between early blind and sighted on an imagery related task and experimentally explained such differences is a study conducted by Reiser, Lockman, and Pick, 1980. The differences found were not attributed to any visual imagery deficit in the early blind per se, but to the blind being less familiar with the imagery task put before them. Indeed, comparing two other studies (O'Connor & Hermline, 1975; Worchel, 1951), it seems that some of the differences found between blind and sighted, previously attributed to the lack of visual imagery in the early blind, may actually have been the result of the early blind being less familiar with some aspect of the task than were sighted subjects. These two studies used the same form discrimination task but found different results. Using common simple shapes Worchel found the early blind performed at an inferior level to sighted on the task. However, using nonsense shapes O'Connor and Hermline found no difference between blind and sighted on the form discrimination task. In short the deficit in the early blind's performance on this task seems to have been a function of the material used. Possibly the sighted were more familiar with the objects used in the Worchel study than were the blind, thus contributing to the differences found. In another study, differences found between the blind and sighted may have also been due to the early blind being less familar with the task used than were the sighted (Marmor, 1977). However, the interpretation put forth was that the early blind lacked the visual imagery in which to efficiently complete the task. In this study the regular print alphabet was used, a medium which the early blind have relatively little exposure.

The aim of the present study is to again investigate the visual imagery of the early blind. The particular imagery task under study involves the shrinking and enlarging of images. Such image manipulations have a direct impact on how people imagine environmental stimuli. Forming a cognitive map of a large scene such as a college campus requires downsizing the scene in order to fit the map into the image system (Weber & Malmstrom, 1979). Conversely, forming a clear image of a small detail requires enlarging that small detail into a larger image (Kosslyn, 1980). In this way, small details can be brought into focus. These are situations in which the ability to shrink and enlarge images becomes fundamentally important. If the early blind are found to perform poorly on such image manipulations, these deficits may help explain why the early blind tend to form poor cognitive maps and other related images which require shrinking and enlarging of images.

The early blind's ability to enlarge and shrink images has at least one other important consequence. The manner in which the early blind perform such tasks may lend support to one or the other hypothesis stated above, i.e., whether the early blind have limited visual imagery or not. If, for example, the difference in performance between the blind and sighted is qualitative, this would suggest the early blind rely on some nonvisual mode of processing which the sighted do not use, a qualitative difference in processing. This would support the No Visual Imagery Hypothesis. If, however, the difference between blind and sighted is quantitative, or a matter of degree, this would suggest the early blind use the same visual imagery processes as the sighted on the shrinking and enlarging manipulations, but that the visual imagery processes of the early blind are limited in some degree or quantity. This would support the Limited Imagery Hypothesis. A qualitative difference would be indicated if the images which the early blind enlarge and shrink are distorted in ways not found in the images of the sighted. A quantitative difference or one of degree would be indicated if say both the blind and sighted form distorted images in a like manner, the blind to a greater extent than the sighted. For this reason the present study examines the nature and accuracy of the images which the blind and sighted form through the shrinking and enlarging manipulation. Also certain introspective data is recorded. Subjects are asked to what extent they use a given imagery modality on the imagery tasks performed in the present study, i.e., visual/spatial, verbal, tactual, kinesthetic, or some other type of imagery. Possibly the differences between blind and sighted can be further depicted in the different imagery preferences.

## Experiment 1

This experiment examines the accuracy with which the early blind and sighted were able to enlarge and shrink images. The images used were of two sizes, large and small. In this way, the effect which the size of the image had on the enlarging and shrinking process was assessed. The images to be manipulated were relatively simple, involving only one simple shape per image.

### Method

Subjects. A total of 20 subjects participated: 10

early blind (EB) and 10 sighted (SE) subjects. To be classified as early blind a subject had to have lost his/her sight before his/her third birthday. All early blind subjects were totally blind since birth. The average chronological age of the early blind and sighted groups was 28.4 and 26.8 years, respectively. Subjects were matched for age across groups within a three-year span. Subjects were not matched for age to a more exact extent because of the limited availability of blind subjects. Each subject participated in both Experiments 1 and 2, which required a total of one hour.

Design and Procedure. This was a multi-factor experiment with repeated measures on some factors (Winer, 1972). Three factors were manipulated. For the first factor subjects were either early blind or sighted. The second factor concerned the size of the environmental stimulus to be imagined by subjects, either a small or large map. The third factor concerned how images were manipulated: in an enlarged form; a shrunken form; or in the same size scale as the original environmental stimulus or map. This was a 2 x 2 x 3 experiment. The subject factor was a between-subjects factor, and the other two factors were within-subject factors.

Subjects were seated in front of a draftsman's table. The top of the table was 91.5 cm by 60.3 cm in dimension. The table top was parallel to the floor. The same chair was used throughout the experiment. Using the same table and chair insured that subjects were within a uniform arm's length from the material placed on the table. Before beginning the experiment sighted and blind subjects were blindfolded and read a pre-test disclosure statement.

A trial began with the presentation of a map on the center of the table. Once a map was presented, the subject had to tactually encode that map, and was instructed to form an image of the map. Then subjects reproduced this image of the map in all three image manipulation conditions: no enlarge/no shrink, enlarging, and shrinking image conditions. The order from which these three image manipulation conditions were administered per map was randomly determined. Subjects were presented with a total of six large maps and six small maps. Half the subjects within a given group were administered small maps first while the other half received large maps first.

The maps consisted of wooden shapes glued on a flat wooden backing. The backing for large maps was 25.5 by 25.5 cm. The backing for small maps was 12.75 by 12.75 cm One shape was placed on each map; either a square, triangle or circle. Squares on the large and small maps measured 3 cm and 1.5 cm per side, respectively. The circles on the large and small maps measured 3 cm and 1.5 cm in diameter, respectively. The triangles on the large map measured 3 cm high and 3 cm across the base. The triangles on small maps measured 1.5 cm height and base. All shapes were raised 0.6 cm above the backing of the map.

Two of the six maps presented to a subject within a size condition had the same shape on it. The shapes on all 12 maps presented to a subject appeared in different locations of the map, thus avoiding any within subjects practice effect. The placement of shapes was balanced across size conditions. Half the subjects per group received a certain set of maps in the large condition while the other half of the subjects received this same configuration in the small map condition.

Tactual Encoding. Subjects were allowed to run their hands across the map in any manner which they saw fit, with no time restrictions. Subjects were able to tactually scan the map until they felt they had formed a clear image of where the shapes were located, with respect to the square backing on which the shapes appeared.

No restrictions were placed on the method or time of tactual exploration for a specific reason. Berla (1981) found that restricting the way blind subjects scanned material interfered with how well subjects were able to encode the material. Possibly this is because blind individuals over a certain age have a habitual way of tactually scanning material, interfering with these learned patterns confuses blind individuals. In short, to avoid this confusion, blind subjects were allowed to freely scan the map with no constraints, as were sighted subjects. The subjects signalled when they had completed encoding a map. No record was kept of how much time subjects spent tactually encoding material. After a map was encoded it was reproduced in one of the three image manipulation conditions. This was done until each subject reproduced all three image manipulations per map. Prior to each image manipulation condition the map was removed and paper was placed on top of the table. This paper was the same dimension as the table. Subjects reproduced their images on this paper. One piece of paper was used per image.

No Enlarge/No Shrink Condition Under this condition subjects were to reproduce the image of each map, the reproduced image being the same size as the actual map. Subjects imagined an image on the paper placed on the table. This image was formed on a particular spot on this paper. To guide subjects as to where to form their images, subjects were given two reference points, called the "No Enlarge/No Shrink" reference points. These reference points were specific dots located on the paper and corresponded to the lower left and lower right hand corners of where the image was to be projected. In the small image conditions these points were 12.75 cm apart. In the large image conditions these points were 25.5 cm apart. The experimenter placed the subjects left and right hand index fingers on the left and right lower dots, respectively. From these reference points, subjects were to imagine the edges of the map forming a square on the large piece of paper the same size scale as the actual edges of the map, the reference points being the left and right hand corner of this imagined square.

Within these imagined squares, subjects were to imagine the target shape (for example, a triangle) in its respective location.

After subjects had formed this image in the prescribed location, the experimenter asked the subject to put an ink dot where he/she imagined that shape was located on the paper. The experimenter would then mark the dot as to what shape it represented.

Shrinking Image Condition. Under this condition subjects were to shrink their images. To do this subjects were first asked to form their images on the same size scale as in the no enlarge/no shrink condition using the "no enlarge/no shrink" reference points which the experimenter placed subjects index fingers on. After this image was formed the experimenter moved both subjects' index fingers placed on the no enlarge/no shrink reference points in toward the center of the paper at a 45 degree angle to new reference points. These new reference points were called the "shrunken size" reference points and were represented by dots on the paper placed on the table. As subjects' index fingers were moved inward, the subject was to shrink the image, bringing in all corners at a 45 degrees angle a distance equal to the distance between the "no enlarge/no shrink" and the "shrunken size" reference points. After subjects had shrunk their image in this way, they then pointed to the imagined form in the image, in the same way as was done in the no enlarge/no shrink condition.

Enlarging Image Condition. This condition involved the enlarging of images. This was done in much the same way as the other conditions. That is, first a regular same size image was formed using the "no enlarge/no shrink" reference points. Second, the experimenter moved the subject's index fingers out at a 45 degree angle to the "enlarged size" reference points. Third, subjects were to enlarge their image according to how far out the reference points were moved. Fourth, subjects were to point to the imagined form in the image.

In respect to the above conditions, the dots representing the reference points were placed on each piece of paper used to reproduce the images prior to the experiment. This made a total of six dots placed on each piece of paper, two dots per condition. In this way the experimenter knew exactly where to move a subject's fingers. The actual shrinking or enlarging of maps corresponded to shrinking maps to half their size or enlarging them to twice their size, although terms such as twice or half as much were never used with subjects. Instead, subjects were to judge how far to enlarge or shrink their images according to the amount of distance the subject's fingers were moved between the no enlarge/no shrink reference points and the enlarged size or shrunken size points, respectively. It was thought that the blind might not be as familiar with such terms as "half" or "twice" the size at a conceptual level as were sighted. At any rate, the aim was to measure the imagery ability associated with such manipulation, and not the conceptualization of terms.

Prior to the actual trials it was made sure that subjects understood how the reference points moved in or outward at a 45 degree angle. It was also explained that the center of the enlarged, shrunken, and no enlarge/no shrink images was the same, that the sides just expanded outward. This was done by presenting subjects with three example maps, a shrunken map, an enlarged map and a same size map. The sizes of the example maps were between that of the large and small maps used in the actual trials. The no enlarged/no shrink size, enlarged size and shrunken size example maps were made on a backing 19, 38, and 9.5 square cm, respectively. Each example map had a square shape glued on the map surface. Each square was raised 0.6 cm above the backing of the map and measured 1.8, 3.6, and .9 cm square for the no enlarge/no shrink, enlarged and shrunken example maps, respectively. These example maps were laid on the table with the smallest on top of the middle size map on top of the large map. In this way the paradigm could be explained to subjects. After subjects understood the paradigm the example maps were removed. At that time subjects had to reproduce the sample maps as he/she would in an actual trial.

The dependent variable consisted of assessing the accuracy of subjects dot placement of estimated imagined forms. This was done in two ways. First, a straight-line distance was measured from where subjects' dots were placed on the paper to where such dots should have been placed. This was the straight-line or overall error. Second, an (X,Y) Cartesian coordinate was calculated for each point estimate. The origin of this coordinate system was the lower left hand corner of each map. Subjects', X and Y responses were subtracted from the correct X and Y coordinates to obtain a X and Y coordinate error. The X-coordinate error was thought to represent a horizontal shift of the object within an image. The Y-coordinate error represented a vertical shift of the object within the image. Third, an introspective measure was recorded. Subjects were asked to report what percentage of various types of imagery they thought they used on the manipulation task. The various types of imagery included: visual/spatial; verbal; kinesthetic; and tactual. Each imagery type was defined before introspective accounts were recorded. In this way subjects had a uniform definition as to what was meant by the various types of imagery. Subjects were instructed to differentiate each of these imagery modes according to the given definitions (see Appendix E). Further, subjects were instructed to make their different percentage estimates sum to 100 percent. This introspective measure was taken after subjects had completed both the experiments.

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Insert Figure 1 about here.

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Results

Straight-Line Error. The data for the straight-line error rate is displayed in Figure 1. As a main effect, the sighted performed significantly better than the blind with mean straight-line error of 4.73 and 7.83 cm for sighted and blind, respectively, $F(1,18) = 13.47$, $p<.0018$. There was also a significant main effect for the size of the map, small maps having a significantly smaller straight-line error rate than large maps, with means of 4.54 and 7.99 cm for small and large maps, respectively, $F(1,18) = 84.22$, $p<.0001$. There was also a significant main effect between the enlarge, shrink and no enlarge/no shrink conditions for the straight-line error rate, with the respective means of 9.96, 3.21, and 5.66 cm, $F(2,36) = 215.8$, $p<.0001$.

All possible interactions for straight-line error were significant. The interaction concerning the group (blind or sighted) by map size (large or small maps) straight-line error was significant, $F(1,18) = 7.43$, $p<.0139$. Also the group by image manipulation condition (enlarge, shrink or no enlarge/no shrink conditions) for straight-line error was significant, $F(2,36) = 22.03$, $p<.0001$. Further, the image manipulation condition by map size interaction for straight-line error was significant, $F(2,36) = 22.73$, $p<.0001$, as was the three way interaction between group by image mainpulation condition by map size for straight-line error, $F(2,36) = 4.07$, $p<.0255$. The analysis of variance summary table and means for this data are given in Tables 1 and 2 of Appendix E.

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Insert Figure 2 about here

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*X*, *Y* *Coordinate Error*. Figure 2 is a graphic display of the mean error associated with the X- and Y-coordinates. The negative and positive signs represent an underestimate or overestimate of the actual coordinates, respectively. Looking at the error associated with the X-coordinate, subjects responses were quite accurate, with both the blind and sighted performing at a similiar level, $F(1,18) = .08$, $p<.7748$. The main effect for image manipulation condition (enlarge, shrink, or no enlarge/no shrink) for the X-coordinate error across blind and sighted was significant, with mean errors of -0.10, 0.43 and 0.89 cm for the enlarged, shrunken and no enlarged/no shrink conditions, respectively, $F(2,36) = 7.30$, $p<.0022$. Also the interaction between the image manipulation condition and map size for the X-coordinate error was significant, $F(2,36) = 7.81$, $p<.0015$. An analysis of variance summary table and means for the X-coordinate are given in Appendix E, Tables 3 and 4.

Looking at the error associated with the Y-coordinate, somewhat different results were found than for the X-coordinate. As can be seen in Figure 2, both blind and sighted tended to underestimate the Y-coordinate, the blind tending to underestimate the Y-coordinate to a significantly greater degree than the sighted, $F(1,18) = 13.48$, $p<.0017$. The mean Y-coordinate error for blind and sighted was -6.94 and -3.83 cm, respectively. Also the main effect for image manipulation condition for the Y-coordinate error was significant, with a mean error across blind and sighted for enlarge, shrink and no enlarge/no shrink conditions of -8.59, -2.65, and -4.92 cm, respectively, $F(2,36) = 151.14$, $p<.0001$. Unlike the X-coordinate, the main effect for map size for the Y-coordinate error was significant, with the mean error for large and small maps being -6.99 and -3.87 cm, respectively, $F(1,18) = 65.99$, $p<.0001$.

Also all of the possible interactions for the Y-coordinate error were significant. The group by image manipulation condition for the Y-coordinate error was significant, $F(2,36) = 15.67$, $p<.0001$. Also, the group by map size condition for the Y-coordinate error was significant, $F(1,18) = 7.25$, $p<.0149$, as was the interaction between map size and image manipulation conditions for the Y-error, $F(2,36) = 16.80$, $p<.0001$. Also, the three way interaction between group by image manipulation conditions by map size for the Y-error was significant, $F(2,36) = 3.42$, $p<.0437$. An analysis of variance summary table and means for the Y-coordinate are given in Tables 5 and 6 of Appendix E.

<u>The Enlarging Process</u>. An analysis of variance was calculated on a subsection of the data. This analysis of variance investigated whether the enlarging process per

se contributed to the difficulty subjects had in forming their images. Two subsections of the data were involved. First, the condition where subjects enlarged a 12.75 cm map to a 25.5 cm map was included. Second, the condition where subjects reproduced the 25.5 cm map without enlarging or shrinking the map was included. The second condition was used as a control for the first condition. The control condition involved no enlarging of the image, whereas the experimental condition involved reproducing the same image as in the control but with an added requirement, that the image be enlarged.

Within a given group the straight-line error did not differ significantly between the two subconditions, $\underline{F}(1,18) = .61$, $\underline{p} < .4445$. This was also the case for the X-coordinate error, $\underline{F}(1,18) = 0.04$, $\underline{p} < .8452$, and Y-coordinate error, $\underline{F}(1,18) = 0.05$, $\underline{p} < .8322$. This suggests that the enlarging process per se was not an important factor for either the blind or sighted. However, the sighted straight-line error was significantly less than the blind straight-line error across subconditions, $\underline{F}(1,18) = 15.87$, $\underline{p} < .0009$. Also, the Y-coordinate error rate for the sighted was significantly less than the blind Y-coordinate error, $\underline{F}(1,18) = 17.37$, $\underline{p} < .0006$. An analysis of variance summary table for this sub analysis is given in Appendix E, Table 7.

<u>The Shrinking Process</u>. A comparable analysis of variance was calculated on a different subsection of the

data. This analysis investigated whether the shrinking process per se contributed to the difficulty of the task. Two subsections of the data were compared: the condition where subjects shrunk the 25.5 cm map to a 12.75 cm map and a second condition where subjects reproduced the 12.75 cm map the same size it was presented. This second condition was a control condition for the shrinking process, measured in the first of the two subconditions. No significant difference was found between these two subconditions within the blind or sighted regarding the straight-line error, $\underline{F}(1,18) = .84$, $\underline{p}<.3705$, X-coordinate error, $\underline{F}(1,18) = 1.23$, $\underline{p}<.2811$, or Y-coordinate error, $\underline{F}(1,18) = 2.22$, $\underline{p}<.1536$. This suggests the shrinking process per se did not contribute to the difficulty of the task for either the blind or sighted. However, the sighted straight-line error was significantly less than the blind's error rate across the two subconditions, $\underline{F}(1,18) = 4.99$, $\underline{p}<.0385$. Also, the Y-coordinate error for sighted was significantly less than the blind Y-coordinate error across subconditions, $\underline{F}(1,18) = 6.38$, $\underline{p}<.0211$. (See Appendix E, Table 8 for the analysis of variance summary table).

Introspective Data. The blind reported using visual/spatial, verbal, kinsthetic, and tactual imagery modes an average of 48.40, 3.5, 27.4, and 20.70 percentage of the time, respectively. The sighted reported using these same types of imagery 40.8, 25.8, 26.1, and 7.2 percentage of the time, respectively. The only significant difference between blind and sighted was in the verbal imagery condition, where the blind utilized significantly less verbal imagery than the sighted, $\underline{F}(1,18) = 8.59$, $\underline{p}<.0089$. The blind did report using more tactual imagery than the sighted, however, this difference was not statistically significant, $\underline{F}(1,18) = 2.33$, $\underline{p}<.1446$. This is most likely due to the large variability among subjects. (See Appendix E, Tables 9 and 10 for a summary analysis of variance table and means for the introspective data).

## Discussion

The data was consistent. The sighted were more accurate at forming images than the blind. This held true whether the image was small or large, and whether the image was shrunk, enlarged or reproduced on the same size scale. The results further indicated that the deficits found in the early blind's performance are not the result of the enlarging or shrinking process per se. The image manipulations did not cause either the blind or sighted significant deficits in performance.

These findings seem to rule out at least one possible explanation for why the early blind tend to form poor cognitive maps of large stimuli. This explanation argues that the difficulty the early blind have in the formation of these cognitive images is in part a product of having to shrink the environmental stimuli down into a managable image size. The present results indicate the early blind are proficient at performing such shrinking operations. Also, the present results are inconsistent with another explanation, one which attempts to explain why the early blind may tend to form inaccurate images of smaller objects. This explanation holds the early blind's ability to image small details is adversely effected by having to enlarge such small stimuli to an image that can be focused on in more detail. However, the present results indicate the blind have little difficulty enlarging images.

Rather, the present study points to other deficits in the imagery of the early blind. One area deals with the size of the image to be processed. In the present study the relative deficits shown by the early blind tended to increase as the size of the image increased. These results suggest the imagery system of the early blind is relatively inefficient with larger images. Why this is so is unclear. It may be that the process of synthesizing the parts of a larger image is difficult for the blind, the small tactile percepts on which the blind rely being hard to synthesize together. As such the blind may process large images as though they are a composite of small images, rather than synthesizing the parts of the large image into one whole. If true, this would be a relatively inefficient way for the blind to process large compared to small images and thus explain the blind's relative difficulty with large images.

The present results suggest other differences between blind and sighted. One such difference can be seen by breaking the overall error component into the X- and

Y-coordinate errors. Specifically, the results indicate that there were no significant error for either blind or sighted with the X-coordinate or horizontal estimates. Both the blind and sighted were accurate in respect to the X-coordinate. Rather, for both blind and sighted, the error occured in the Y- or vertical coordinate. Here both groups tended to underestimate the actual Y-values, the blind tending to form significantly greater underestimates than the sighted. These results indicate there is a fundamental difference between the X- and Y-coordinates, the vertical estimate being more difficult.

The explanation for such a finding may lie in the methodology of the study. Recall that the reference points were the lower corners of the map. A horizontal estimate involved making an estimate between these two points. As such, in making horizontal estimates, subjects were aided a great degree by the location of the reference points as well as their own body image. However, in making a Y- or vertical estimate, subjects had to reach out away from their body, not aided a great deal by the reference points or their body image. This may have made the vertical estimates more difficult, involving a spatial depth dimension, reaching out away from the body which was not necessary in making horizontal estimates. That both the groups tended to underestimate the Y-coordinate seems to suggest a general hesitancy to venture out from the reference of the body, the blind being significantly more hesitant than the sighted. This suggests the early blind have relateively limited imagery depth cues to work with out away from their body. Conversely, the blind had no difficulty with the X-coordinate which suggests such limitations of the early blind's imagery system are, for the most part, isolated to those situations which involve depth cues out away from the body.

The introspective data suggests another difference between the blind and sighted. The blind utilize far less verbal imagery in their formation of images than sighted subjects. This is understandable given the nature of verbal imagery. Verbal imagery is the formation of estimates of distance between objects, e.g. five inches, seven feet, etc. These estimates may require experience with rulers and other tools of measurement, which the blind frequently do not have. This study as well as at least one other (Weber & Kelley, 1972) suggests that sighted use verbal imagery estimates in the formation of visual images, and that verbal imagery aids in the formation of visual images. This suggests that the images of the blind are less accurate at least in one respect, because the blind use no such verbal aids in formation of visual images.

In conclusion it must be asked what implication do these findings suggest about the visual imagery of the early blind. In the introduction two hypotheses concerning visual imagery of the early blind were discussed: the no visual imagery hypothesis and the limited visual imagery hypothesis. It seems the present results are inconsistent with the no visual imagery hypothesis, tending to support the limited visual imagery hypothesis. For one thing the no visual imagery hypothesis must explain how the early blind were able to enlarge and shrink images, without the aid of visual imagery. In particular, how were the blind so accurate on the X-coordinate measure without using at least limited visual imagery? In fact it is not as though these results are isolated illustrations of the early blind's imagery ability. For instance, other studies have shown the early blind are able to perform related imagery tasks, i.e., learning large-scale environments through exposure to small-scale models (Bentzen, 1980; Easton & Bentzen, 1980; Herman, Herman & Chatman, 1980). Like the tasks used in the present study, these tasks would seem to require at least limited visual imagery.

Then, too, the present results suggest the differences found between the blind and sighted are a matter of degree or quantity. The pattern of results is similar between the blind and sighted, the blind having an overall deficit in degree. This suggests the early blind process material using the same modalities as the sighted, but that certain of the modalities of the blind are limited. If the blind were without visual imagery a qualitative difference in the pattern of results should have been found, indicating the blind process images in a different manner or mode of imagery than the sighted.

In short, the present data seems to support the limited visual imagery hypothesis. Indeed, the present study suggests three areas in which the visual imagery of the early blind is defective or limited. In summary, these limitations are: the imagery of the early blind is relatively ill-equiped to process large stimuli, has little depth, and is not aided by verbal imagery. No doubt, further study is needed to specify these, and other possible limitations of the visual/spatial imagery of the early blind. With such knowledge it may be possible to improve the visual imagery of the early blind. After all, verbal imagery, if it does not exist in the blind at present, might be taught, under the assumption verbal imagery is a learned imagery experience. Once taught, this verbal imagery might have a positive influence on the visual imagery of the early blind.

## Experiment 2

Experiment 2 had subjects enlarge or shrink images as was done in Experiment 1, except that the images to be enlarged or shrunk involved three shapes, not one as in Experiment 1. Using three shapes per image map increased the spatial component of the task, requiring the integration of three objects in space. The crucial question is what effect will increasing this spatial memory component have on the early blind's ability to shrink and enlarge images. If this spatial memory component is a contributing factor in explaining the deficits in the early blind, increasing this memory component should result in a disproportionate deficit in the early blind's performance.

Method

Design and Procedure. The only difference between this experiment and Experiment 1 is that the maps used in this second experiment had three shapes per map, rather than the one shape per map as in Experiment 1. As in Experiment 1, this experiment was a multi-factor experiment. The factors were the same as in Experiment 1: the subject factor, blind or sighted; the size of the map, large or small maps; and the image manipulation condition, shrunken, enlarged or same size condition. The subjects factor was the only between-subject factor.

The same table, chair and paper on which images were reproduced in Experiment 1 was used in this experiment. Also the procedure was the same as in Experiment 1 requiring subjects to tactually encode maps, forming an image of each map. These images were then transformed onto a piece of paper placed on the table as in Experiment 1. On this paper subjects were then instructed to either enlarge, shrink or form the image the same size. Images were enlarged or shrunk by moving the "no enlarge/no shrink" reference points "out" or "in" at a 45 degree angle as in Experiment 1. The order of these three conditions within each map was determined at random. Finally, the reproducion of these images was accomplished by the experimenter calling out each of the three shapes on the map in a random order, at which time the subject placed a dot where he/she judged that shape should be on the paper. After the subject had placed a dot on the paper the experimenter made sure the subject returned his/her fingers to the reference points before calling out another shape. This insured independent placement of dots within a map. The accuracy of subjects' judgements was measured in the same way as in Experiment 1, using both a straight-line error distance and a Cartesian coordinate system. Also the same introspective measure was used in this experiment as was used in Experiment 1.

The only difference between Experiment 2 and Experiment 1 was the complexity of the maps used. Each map was composed of three shapes. The three shapes placed on each map were a circle, square, and triangle. The shapes and backing used for each map were the same dimensions as in Experiment 1. Objects were placed on each backing in the same relative position as they appeared in the maps in Experiment 1. The only difference was that three shapes appeared on one map and not separately. Three maps in Experiment 1 were combined into one map in the current experiment: each map having three different shapes on it. Given that each subject received 12 maps in Experiment 1, this meant that subjects were presented with a total of 4 separate maps in this experiment. Half the subjects received small maps first while half received large maps first.

The configuration of shapes within each of the four maps given to a subject were all different, making a total of four different configurations. Half the blind and sighted subjects received configurations 1 and 2 in the small map condition while receiving configurations 3 and 4 in the large map condition. The other half of the blind and sighted subjects received configurations 3 and 4 in the small map condition and configurations 1 and 2 in the large map condition. Between small and large conditions a particular configuration differed only in the size of the objects used and not in relative placement of objects. In this way all subjects received four different configurations within maps, thus avoiding any practice effect. Likewise, the large and small maps were equal across blind and sighted relative to the placement of shapes on maps.

Prior to the actual trials an example map was given. The backing of the example map was 19 cm square. The dimension of each shape on the sample map was: square, 1.8 cm per side; triangle, base and height of 1.8 cm; and circle, 1.8 cm in diameter. Subjects reproduced this example map first in the no enlarge/no shrink condition, then in the enlarged followed by the shrunken condition.

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Insert Figure 3 about here

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## Results

Straight-line error. The data for the straight-line error is graphically presented in Figure 3. The overall analysis of variance for the straight-line error indicated the main effect for group was significant, $F(1,18) = 12.40$, $p<.0024$. The mean straight-line error for blind and sighted was 7.59 and 3.87 cm, respectively. The main effect for the straight-line error between image manipulation conditions was significant with the mean for the enlarged, shrunken and no enlarge/no shrink conditions of 9.44, 2.78, and 4.98 cm, respectively, $F(2,36) = 162.32$, $p<.0001$. Also, the straight-line error between map size conditions was significant with means for small and large maps of 3.87 and 7.59 cm, respectively, $F(1,18) = 78.41$, $p<.0001$.

All two-way interactions for straight-line error were significant. The straight-line error, group by image manipulation interaction was significant, $F(2,36) = 11.70$, $p<.0001$. Also, the straight-line error for group by map size interaction was significant, $F(1,18) = 4.74$, $p<.0430$. Further, the straight-line error for image manipulation by map size interaction was significant, $F(2,36) = 26.59$, $p<.0001$. (See Appendix E Tables 11 and 12 for analysis of variance summary and means for the straight-line error.)

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Insert Figure 4 about here

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(*X*, *Y*) Coordinate Error. Figure 4 displays the X- and Y-coordinate errors. The analysis of variance for the X-coordinate revealed nothing of significance. However, all main effects for the Y-coordinate error were significant. An analysis of variance indicated the main effect for group was significant with a mean Y-error for blind and sighted of -5.89 and -3.27 cm, respectively, $\underline{F}(1,18) = 10.40$, $\underline{p}<.0047$. Also, the main effect for the image manipulation condition for the Y-error was significant with mean Y-error for enlarging, shrinking, and no enlarge/no shrink conditions of -7.84, -1.96, and -3.94 cm, respectively, $\underline{F}(2,36) = 123.25$, $\underline{p}<.0001$. Further, the main effect for map size regarding the Y-coordinate error was significant with the Y-error for small and large maps of -2.86 and -6.30 cm, respectively, $\underline{F}(1,18) = 70.11$, $\underline{p}<.0001$.

All two-way interactions for the Y-coordinate error were significant: group by image manipulation condition, $\underline{F}(2,36 = 11.71$, $\underline{p}<.0001$; group by map size, $\underline{F}(1,18) = 5.49$, $\underline{p}<.0308$; and map size by image manipulation condition, $\underline{F}(2,36) = 13.89$, $\underline{p}<.0001$. (See Appendix E Tables 13-16 for means and ANOVA summary for the X- and Y-errors).

The Enlarging Process. To examine whether the enlarging processes contributed to the difficulties the subjects had with the task, the data was subdivided as in Experiment 1. As in Experiment 1 the results indicated the enlarging process had little effect on the results. The enlarging subcondition did not differ significantly from its control condition in either the straight-line error, 2.84, $p<.1094$; or Y- coordinate error, $F(1,18) = 0.29$, $p<.597$. This suggests the enlarging process did not contribute to the difficulty of the task for either the blind or sighted. However, there was a significant difference between groups. The blind's straight-line error across the enlarged subconditions was significantly greater than the sighted straight-line error, $F(1,18) = 13.57$, $p<.0017$. This was also the case for the Y-coordinate error between the two groups, $F(1,18) = 9.82$, $p<.0057$.

The Shrinking Process. The data was also subdivided in the same way as in Experiment 1 in regard to the shrinking process. Like the enlarging process the shrinking subcondition did not differ from its control for either the straight-line error, $F(1,18) = 1.78$, $p<.1987$, or the X-coordinate error, $F(1,18) = 0.02$, $p,.8996$. Also, as in the enlarging process, the results indicated the sighted significantly out performed the blind across the shrinking subcondition and its control in regard to straight-line error, $F(1,18) = 5.67$, $p,.0284$, or Y-coordinate error, $F(1,18) = 5.05$, $p<.0374$.

However, the results regarding the shrinking process were not entirely consistent with Experiment 1 or with what was found in the current experiment concerning the enlarging process. Specifically, the shrinking process produced significiantly more Y-coordinate error than its control condition, $F(1,18) = 5.87$, $p<.0262$. This indicates that shrinking process contributed to the difficulty of the task.

shrinking process contributed to the difficulty of the task. The blind's Y-coordinate error increased .95 cm when having to shrink their images as compared with the control. The sighted Y-coordinate error increased .08 cm between the two subconditions. That the interaction between group by shrinking subconditions was significant indicates that this increased Y-coordinate error between the control and the shrinking subcondition was a disproportionate increase between groups, $\underline{F}(1,18 = 8.16$, $\underline{p}<.0105$. (See Tables 17 and 18 for an ANOVA summary of this subanalysis.)

Introspective data. The blind reported using the following mean percentages of visual/spatial, verbal, kinesthetic and tactual imagery on the tasks performed in Experiment 2: 51.9, 7.5, 19.7 and 20.9%, respectively. The sighted reported using the following mean percentage of the respective types of imagery: 44.0, 23.5, 21.5, and 11.0%. As in Experiment 1, the only significant difference is in verbal imagery, where the blind reportedly used significantly less than the sighted, $\underline{F}(1,18) = 7.22$, $\underline{p}<.0150$. (See Appendix E, Tables 19 and 20 for ANOVA summary and means.)

Experiment 1 and 2 Compared. An analysis of variance comparing the two experiments indicated there was a significant improvement in the second experiment in both straight-line error, $\underline{F}(1,18) = 5.96$, $\underline{p}<.0252$ and Y-coordinate error, $\underline{F}(1,18) = 10.90$, $\underline{p}<.0040$. The mean straight-line and Y-coordinate errors for Experiment 1 were

6.28 and -5.39, respectively. The mean straight-line error and Y-coordinate error for Experiment 2 were 5.73 and -4.58, respectively. (See Tables 21 and 22 for ANOVA and means for this analysis between Experiment 1 and 2).

Discussion

For the most part the present experiment verifies and extends the results of Experiment 1. As such the conclusions reached in Experiment 1 are generally applicable to the present experiment and will not be further elaborated upon. However, there are some slight differences. While the pattern of results were the same between the two experiments, the overall performance was significantly better in the second, compared to the first experiment. This clearly suggests that adding a reasonable number of objects within an image, as in Experiment 2, thereby making it more complex, does not necessarily result in that image being more difficult to enlarge, shrink, or otherwise reproduce. Indeed, the improved performance in the second experiment may suggest that having three objects per image, as in Experiment 2, allows the blind and sighted to form a spatial relationship among objects, not possible when only one object is present per image. This added spatial component in Experiment 2 may have aided subjects in the formation of images by providing a larger network of spatial relations. Both blind and sighted may benefit by such a network.

While there was an overall improvement in Experiment 2, the added spatial component of the present experiment may have also caused an isolated deficit in performance. Specifically, the shrinking process was shown to adversely effect the blind's performance in the present experiment, unlike the previous experiment. The results indicate the blind actually had difficulty shrinking the more complex images, (Experiment 2), but not the simpler images (Experiment 1). It may be that having to maintain more objects in a spatial relationship made it more difficult for the blind to shrink their images, while maintaining such a relationship. This added spatial component may have caused the blind to have difficulty with the shrinking process.

While these explanations for the differences between the two experiments are intriguing, there is a second, less appealing interpretation for such differences. That is, these differences could be the result of a practice effort. That with practice in Experiment 1, subjects improved in the second experiment. There is no way of knowing how such an effect might influence the results. Yet, it is quite noteworthy that even with this possible practice effect, the differences between blind and sighted found in Experiment 1 did not dissipate in the current experiment. This suggests such differences reflect a reliable fundamental difference between blind and sighted.

## FIGURES CAPTIONS

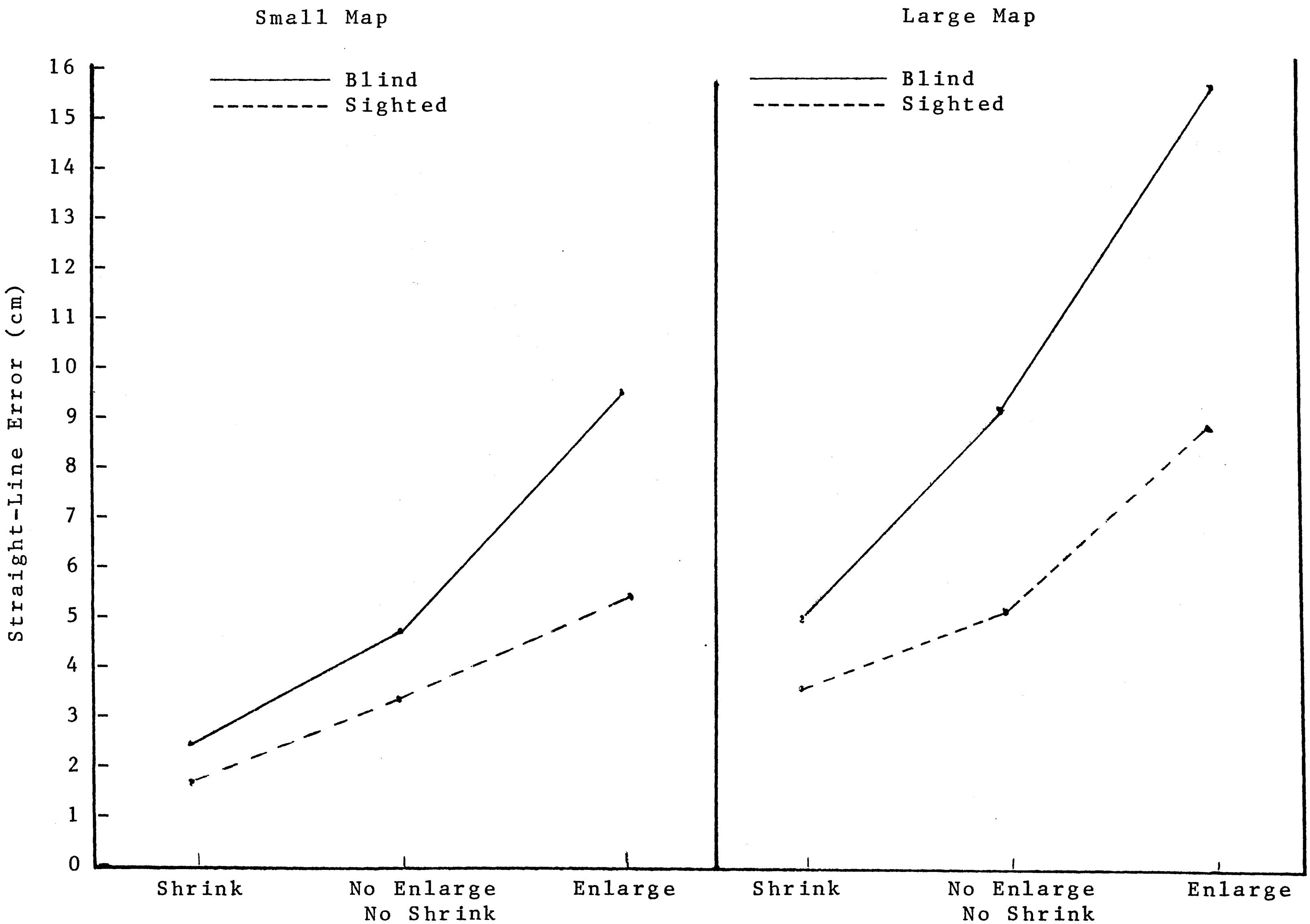


Figure 1
Image Manipulations

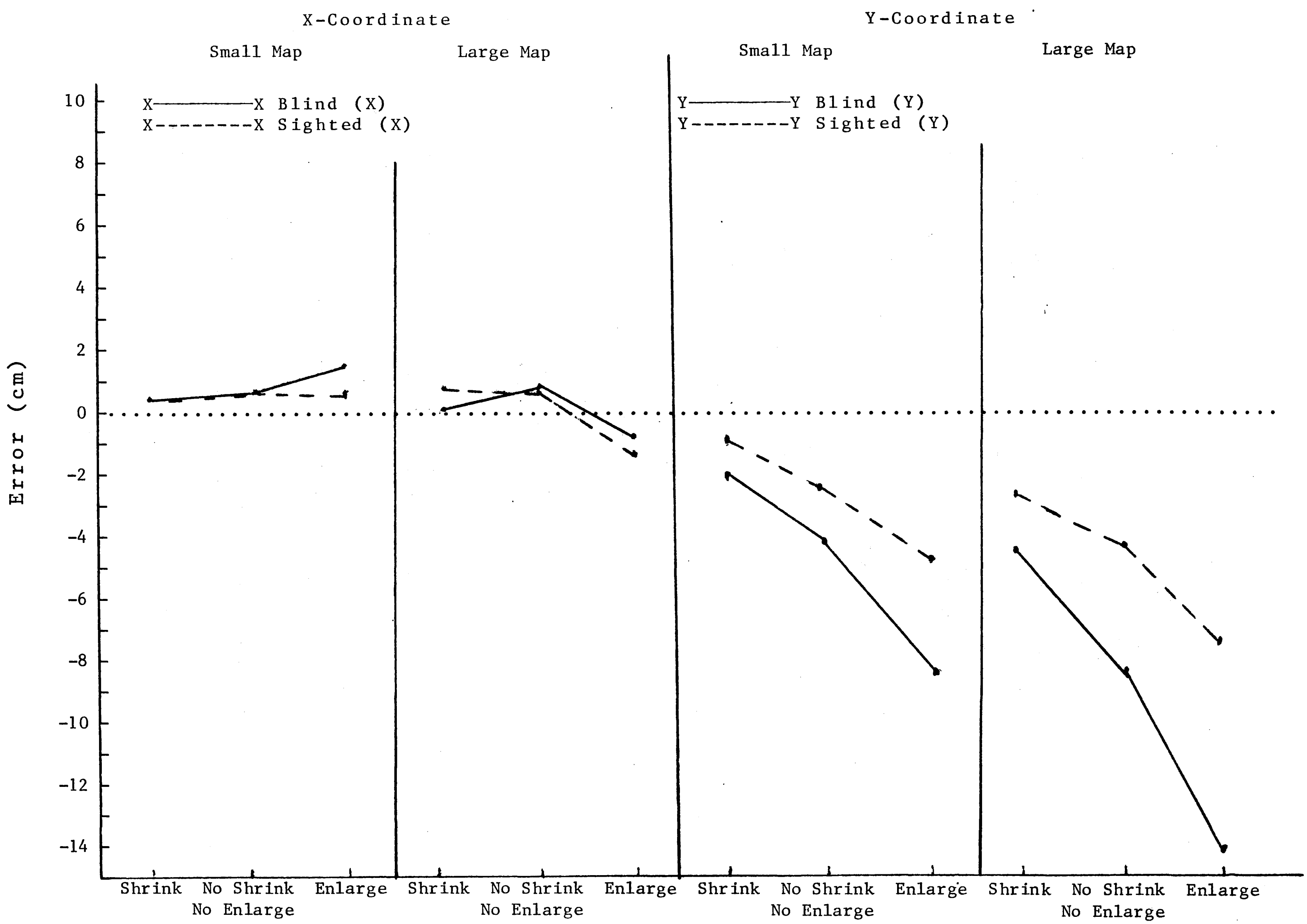


Figure 2
Image Condition

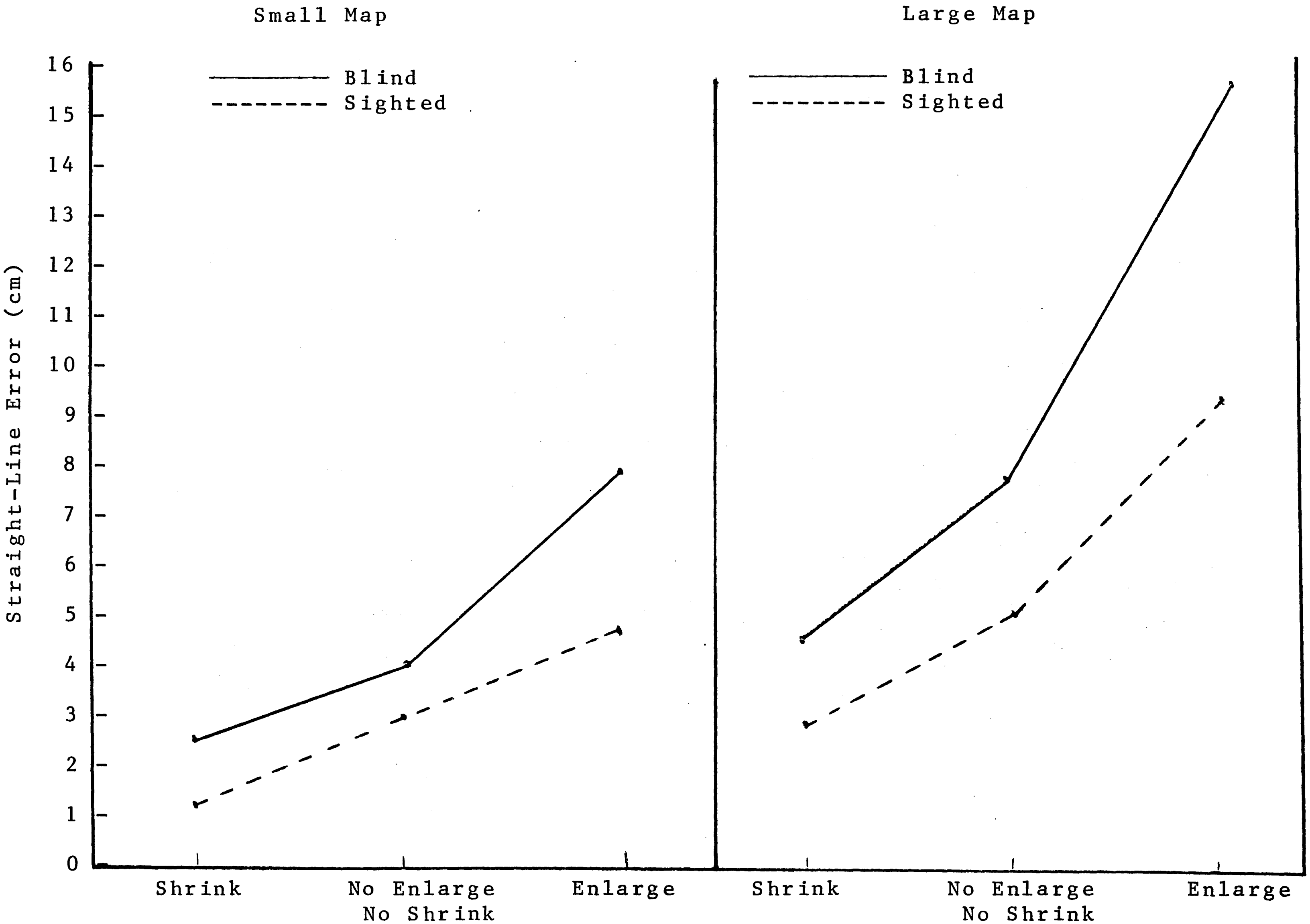


Figure 3
Image Manipulations

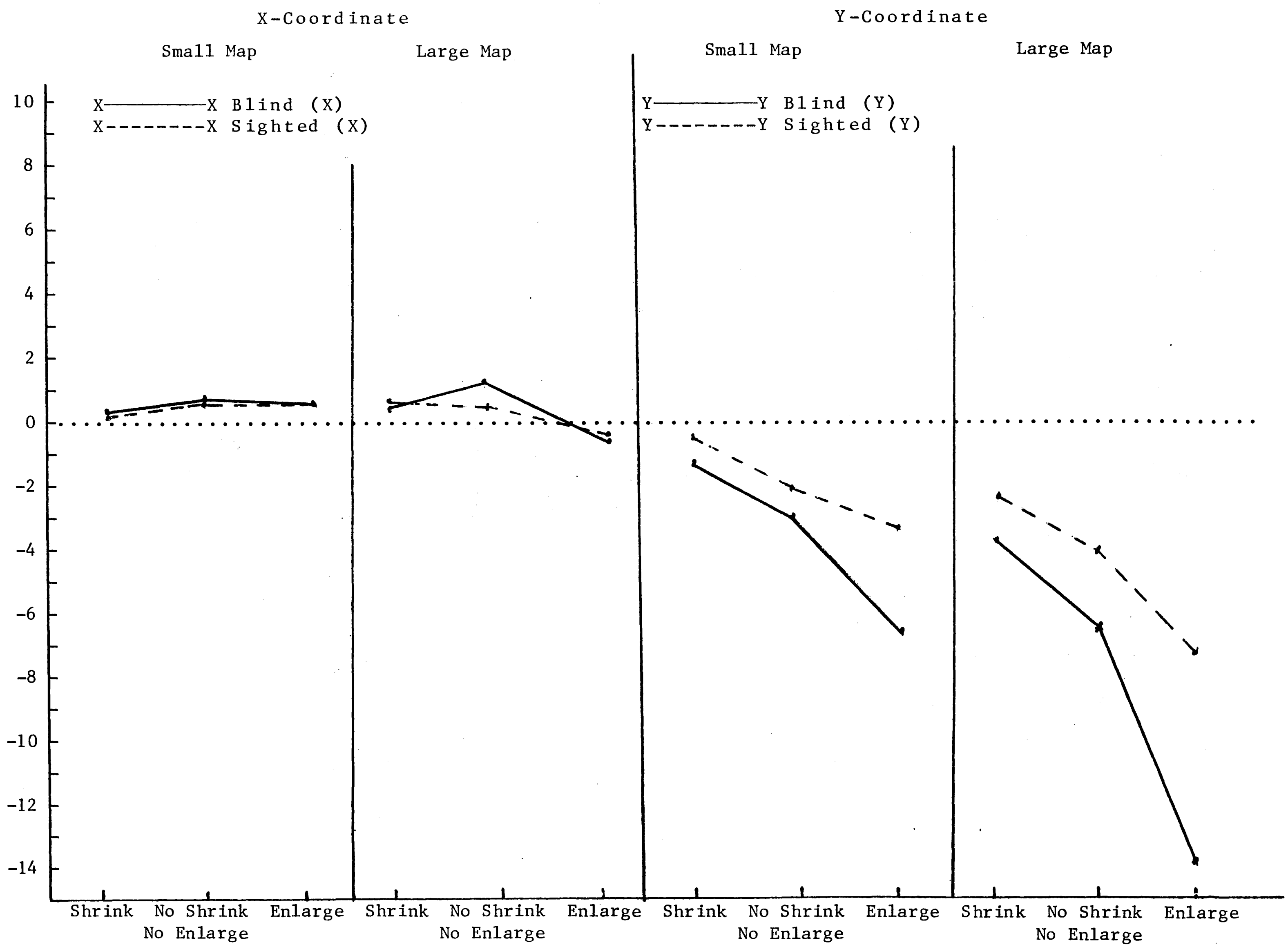


Figure 4
IMAGE CONDITION

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APPENDIXES

# APPENDIX A

## Definition and Demographics of Blindness

## Introduction

This appendix provides a definition of legal blindness as well as demographic data concerning the blind.

## Definition of Blindness

The condition commonly subsumed under the heading of blindness actually fall into two categories: total blindness, and legal blindness. Total blindness is easy enough to understand. It is sightlessness -- the total absence of any light or visual perception. Legal blindness is defined in a formula adopted in 1934 by the American Medical Association, subsequently incorporated in the Aid to the Blind Title of the Social Security Act of 1934, and further embodied into law in federal and state statutes providing various special services for the blind. This basic definition which is still in use is:

> Central visual acuity of 20/200 or less in the better eye with corrective glasses or central visual acuity of more than 20/200 if there is a visual field defect in which the peripheral field is contracted to such an extent that the widest diameter of the visual field subtends an angular distance of no greater than 20 degrees in the better eye (Koestler, 1976 p. 45).

In layman's terms, this means that a person is considered legally blind if: (a) even with perfectly fitted eyeglasses, his/her better eye can see no more at a distance of 20 feet than a person with normal vision can see at a distance of 200 feet; and/or (b) the central visual field is so restricted that he/she can only see objects within a 20 degree arc, in contrast to the normal visual ability to see objects in much wider arc above, below and on each side of the line of sight. In summary, under the legal definition, saying a person is legally blind does not necessarily mean he/she is without any sight. Instead, legal blindness designates a wide continuum from total blindness to partial sightedness.

A word about how this acuity level is measured is relevant here. The procedural manner through which legal blindness is determined may be made on the basis of the Snellen Chart, whose printed letters are so sized and shaped that the ability to read a certain line from a distance of 10 feet denotes normal vision, designated as 20/20. The person who, from that distance, is unable to see more than the single large E which is the chart's top line is said to have 20/200 vision. This is the entry point of legal blindness. Unfortunately such a method is far from exact.

## Prevalence

The latest estimate on the incidence and/or prevalence of monocular blindness in the U.S. based on findings from an opthalmological examination of a national probability sample of the U.S. population during the first Health and Nutrition Examination Survey in 1971-1972 was reported by the National Center for Health Statistics (1977). The results showed, in general an estimated 210,000 persons of the total U.S.

population in the 4-74 year age range had visual acuity less than 20/200 in their better eye. For a breakdown of these findings according to age, race, sex and geographic location, see Goldstein (1980). Several disadvantages of this study need to be mentioned. First, only 72.8 percent of the chosen representative sample actually came in for testing. Because of the omission of some 28 percent of the selected sample, the resulting figures are likely to be underestimates. Second, corrected acuity, which legal blindness deals with, was only measured for the 37 percent who brought their glasses, while for the remainder of subjects uncorrected acuity was measured. Third, the age groups under 4 years and over 74 years, whose members usually exhibit a high prevalence of severe visual impairment were omitted. Fourth, other high incident populations also have been excluded, such as institutionalized individuals and American Indians living on reservations where trachoma has not been eradicated. Fifth, usual correction of existing glasses was used instead of making sure that such correction was the best available. Sixth, no measurement of visual field was attempted.

Following such criticisms it would now be ideal to cite other existing studies for comparisons. Yet, other such studies have the common problem of being out-dated. The most recent of these is a survey conducted by the National Health Interview Survey (July 1963-June 1965) of individuals 6 years and older, indicating that approximately 1,227,000 persons suffered from visual impairment. Also a survey of binocular visual acuity among adults was conducted by the National Health Examination Survey in 1960-1962. In general, they found a prevalence rate of those individuals having 20/200 acuity or worse to be 8 per 1,000 in the 18-79 age group. Yet this survey far from escapes the above mentioned problems (See Goldstein (1980) for a further discussion of this and other studies). At any rate, it should now be clear that the reporting of incidence of blindness is far from an exact science and probably misleading at best.

APPENDIX B

Visual and Spatial Imagery

in the Blind

## Introduction

This appendix provides a supplementary and more extensive literature review than was otherwise given in the introduction concerning visual and spatial imagery in the blind. Visual and spatial imagery are dealt with as a single entity under the belief that they are more alike than dissimilar (Baddeley, 1976; Brooks, 1968).

The studies discussed here are divided into five general areas: introspective and self-report studies; form discrimination and spatial orientation studies; mental rotation studies; cognitive mapping studies; and other studies concerning imagery. These divisions are not mutually exclusive, but may help organize the vast array of material.

## Introspective and Self-Report Studies

Jastrow (1888) was one of the first to demonstrate the interaction of visual imagery development and age at which blindness occurred. He interviewed 60 blind people, and found that the early blind reported that their dreams were devoid of visual imagery, whereas the late blind reported experiencing visual imagery frequently in their dreams. On the basis of these findings he concluded that the early blind fail to develop visual imagery although the late blind develop and retain such representations. Fernald (1913) also recorded the introspective reports of an early blind and a late blind person. She found that in place of visual imagery the early blind person used tactual imagery while the reverse was true for the late blinded individual. Also, Singer and Streiner (1966) made inferences about the extent of visual imagery in the blind through their play, fantasy, and dream activities by interviewing 20 early blind children, ages ranging from 8-12 years old. They found in general, as compared to a sighted control group, the blind showed concrete and limited fantasy in their play and dreams, except for a greater reliance on imaginary companions. Consistent with earlier studies it was concluded that such results suggested the early blind have no visual imagery.

Schlaegel (1953) investigated how the age of onset of blindness and visual acuity effects visual, acoustic, kinesthetic, tactual, temporial, olfactory, and gustatory imagery ability. Schlaegel measured these imagery abilities by presenting 125 words or phrases to subjects at which point they were to imagine the content of the presented word or phrase. Subjects then wrote down what sensory modality they used to image that scene, i.e., see, hear, muscle, taste, etc. Unlike the studies described so far which used only totally blind subjects, Schlaegel used both partially sighted as well as totally blind subjects, dividing visual acuity of subjects into three groups. First, those with the best partial vision, i.e., vision better than 5/200. Second, those with intermediate partial vision, i.e., individuals with the ability to at least detect any movement in objects, to at most the ability to count fingers at 5 feet. Third, those with very poor vision, i.e., individuals having only light perception or less. Also within these three divisions subjects were divided into early blind and late blind groups based on the age of onset of the visual loss.

When the blind groups and the sighted were considered as a whole the results revealed that the average subject tended to use visual imagery more than other imagery modalities. The ranking from most dominant used imagery modality to least was as follows: visual, auditory, kinesthetic, tactile/temperature, and olfactory/gustory. However, when the blind groups were divided into those with the best, intermediate and poorest present visual acuity significant differences were found. In general, the results showed that as present visual acuity increased so did utilization of visual imagery. Also important was the age of onset of the visual loss. If the onset of blindness occurred before the age of 6, visual imagery tended to decrease, most pronounced in those subjects with the poorest visual acuity. These findings suggest that whether a visual loss occurred early or late in life, as well as the severity of such a loss, influences the development of visual imagery. Johnson (1980) has since replicated this study conducted by Schlaegel using a tighter control, finding similiar results.

However, Schlaegel noticed that early blind subjects misleadingly reported they "saw" the scene. On further investigation he found what they meant by "saw" was quite different from visual imagery. In particular, given the scene of George Washington they would think of "characteristics" such as his height, frame, color of hair and shape of nose, etc. rather than forming an image. This misleading scenario of events also points to a disadvantage of self-report measures as used above. All self-report measures are subject to the criticism that different criteria may be used in defining the nature of the phenomenon under study, in this case imagery. This problem is particularly critical when comparing two different populations, blind and sighted.

## Form Discrimination and Spatial Orientation

Numerous studies have measured the early blind, late blind and sighted individuals ability to perform a variety of imagery related tasks. The imagery tasks discussed under this section are of two types. First, there are a variety of tasks which investigated the ability to form and discriminate between images of objects which were tactually encoded, what I will term Form Discrimination tasks. Second, there are tasks which investigated the image of one's body in space, or what I will term Spatial Orientation tasks.

Sylvester (1913) was one of the first to objectively measure the early blinds' visual imagery ability. He found that the longer a blind person had sight prior to blindness, the better he/she did on a form board. He concluded (1) those who have had visual experience retain their visual imagery and are assisted by it in the interpretation of their tactual impressions; and (2) tactual imagery, even for those who have no other resource, is not as effective as a combination of tactual and visual imagery. Not only does this suggest that visual perception is a necessary experience for the development of visual imagery as concluded elsewhere but also indicates tactual experiences are less than able to compensate for the loss of visual imagery in the early blindness.

In 1951 Worchel conducted a landmark study concerning the space perception and orientation in the blind. Of primary interest was how the loss of visual perception might influence such processes. Three specific processes were studied: tactual form perception, manipulation of images, and body orientation.

In studying form perception Worchel used three tasks involving the early blind, late blind and sighted. In the first form perception task subjects were given small shapes which they were to tactually explore using only one hand. After exploring a shape subjects reproduced that shape in two ways: through drawings and verbal description. In the second form perception task subjects used both hands to tactually examine larger shapes. Again, after exploring each shape subjects reproduced the shape through drawing and verbal description. In the third form perception task, subjects used one or both hands to tactually explore shapes. Rather than drawing or verbally describing such shapes, subjects were then given four other shapes one at a time to tactually explore. Subjects were to decide which of these four shapes was like the first shape.

Worchel found the early blind were significantly inferior to the late blind and the late blind were significantly inferior to the sighted on the first two form perception tasks irrespective of whether subjects verbally described or drew forms. However, no difference was found between blind and sighted on the third form perception task. Based on these findings Worchel concluded that the differentiating factor was the mode of reproduction. Where the mode of reproduction was through verbal description or drawings the early blind performed poorly. Worchel suggested that verbal descriptions and drawings involve transforming the material into a visual image, an imagery system the early blind were presumed not to have, hence the early blinds' difficulty with such modes of representation. However, on the third form perception task a multiple choice matching mode was used and no difference was found. In essence, Worchel reasoned this third task was a more "pure" form perception task not being influenced by the manner of responding, as were tasks one and two. Because no difference on this "pure" tactual form perception task was found between blind and sighted, Worchel suggested that form perception per se does not require visual imagery, else the early blind would have performed poorly on this third tactual form perception task, the early blind here presumed not to have developed visual imagery. This finding concerning the third form perception task has been confirmed by at least one other study (Ewart &

Carp, 1963).

In the same study Worchel also studied the manipulation of images by the blind and sighted. This task involved presenting subjects with two shapes, one in each hand, which subjects tactually explored. The experimenter then handed subjects four other shapes one at a time. Subjects decided which of these four additional shapes would result if the first two shapes were combined. Worchel found that the early blind performed significantly poorer than the late blind and the late blind performed significantly poorer than the sighted on this task. This was interpreted as indicating that the manipulation of images requires visual imagery, explaining why the early blind, who were presumed not to have visual imagery, performed so poorly relative to the late blind and sighted.

Finally, in this same study Worchel studied the body orientation skills of the blind and sighted. For this purpose a triangle was painted on the floor of a large gym. Blind and blindfolded sighted subjects were led along two sides of the triangle. Subjects were to return to where they started via the hypotenuse. Worchel found that the sighted returned closer to the starting point than the blind. Both the early blind and late blind did not differ on this task. Worchel suggested that this illustrated that along with the manipulation of images, spatial imagery requires visual imagery, hence the early blinds' poor performance. It seemed visualization affects both visual and spatial imagery; this is consistent with the research which has tended to find visual and spatial imagery as highly linked (Braddeley, 1976; Brooks, 1968).

Drever (1955) has also conducted a study investigating several form imagery abilities of the blind. Drever had three separate tasks that blind and sighted children were evaluated on. The first task was a replication of the image manipulation task used by Worchel (1951) where subjects simultaneously held two different wooden blocks, one in each hand, and then were sequentially given four other blocks. Subjects were asked which of the four alternate shapes would result if the first two blocks were put together. Consistent with the results found by Worchel, Drever found the sighted children were slightly superior to the late blind and the late blind were much superior to the early blind on this task. Like Worchel, Drever interpreted these results as indirectly indicating that such a task involved visual imagery, the early blind presumably having no visual imagery in which to efficiently complete such a task.

The second task used by Drever consisted of a spatial orientation task. Subjects were required to tactually scan a peg-board. It was then rotated 180 degrees and the subjects were to replace all the pegs in their original holes. The results indicated that the late blind were superior to the early blind and sighted, the early blind and sighted not differing significantly in performance. This finding was interpreted as indicating the importance of both tactual and visual imagery experiences on such a task, the late blind having both experiences while the sighted only using primarily visual experience and the early blind only having tactual experience on which to rely.

The third task used by Drever was a tactual classification task. Specifically, subjects were presented with three figures. These figures were made up of a combination of pegs put in a peg-board in a particular pattern. One of these three shapes differed either in the number of pegs used or some implied characteristic having to do with the shape of the objects, i.e., the odd ball in the set--subjects were to decide which shape was the "odd ball" shape. Three groups were used in this task: a blind group, a blindfolded sighted group, and a sighted group not blindfolded. The results indicated that the blind subjects performed more like the non-blindfolded sighted subjects than the blindfolded sighted subjects. It seemed that the blind group was able to perform as well as the non-blindfolded sighted subjects. However, the blindfolded sighted subjects were not able to perform as well as non-blindfolded sighted subjects. Drever interpreted this to mean that the blind are able to encode more material through tactual encoding than blindfolded sighted subjects, the blind being more experienced with tactual encoding.

In a more recent study O'Conners and Hermline (1975) also examined the influence of blindness upon the development of spatial imagery. O'Conners conducted two different experiments. The first experiment examined aspects of spatial imagery as they related to form perception and the manipulation of forms. Experiment 2 also examined imagery but the salient feature was the orientation of forms and not so much the shape. This distinction will be made clearer as these two experiments are discussed.

In the first experiment subjects were presented with pairs of shapes. Each shape was a square with a piece cut out of it. Subjects were asked to judge whether the cut out pieces of the different shapes would fit together. These shapes were presented side by side on a piece of cardboard. The shapes were placed on this board in one of two conditions: not inverted or inverted condition. In the not inverted condition the two cut out missing segments of the shapes were placed on the cardbard facing one another, subjects merely had to imaginally move the two shapes together, judging whether they fit. In the inverted condition the two cut out missing segments of the shapes were placed in such a way as not to face one another, requiring subjects to imaginally rotate one of the shapes in such a way that the cut out pieces face one another and then imaginally move the cut out pieces together, judging whether the two shapes fit. Further, O'Conner used three groups: blind, blindfolded sighted, and non-blindfolded sighted. The blind and blindfolded sighted subjects tactually encoded the shapes while the non-blindfolded sighted subjects were allowed to use visual perception.

O'Conner found no difference between blind and blindfolded sighted subjects on this task. O'Conners interpreted this as indicating that visual imagery which presumbly the early blind do not have was not a salient factor in the performance of such a task. It was reasoned that if visual imagery was the salient component the early blind would have been at a disadvantage on this task and such a disadvantage would have been reflected in the results.

It should be noted that this is contrary to an earlier study conducted by Worchel (1951). As mentioned earlier, Worchel found the early blind performed poorly relative to sighted subjects on a similar task. However, the results found by Worchel may be a function of experience and not imagery ability. That is, Worchel used shapes which were familiar to the sighted but may not have been as familiar to the blind. This difference in experience may have contributed to the results found by Worchel. O'Conners on the other hand, used unfamiliar shapes, thus avoiding the problem of one group being more familiar with the material by virtue of neither blind or sighted having ever worked with the shapes prior to the study. Given the prior experiences of the blind and sighted differs, it seems reasonable that prior experience would have such an effect.

O'Conners found at least one additional result of interest in this first experiment. This finding concerns the non-inverted condition as compared with the inverted condition. It was expected that the inverted condition would be more difficult than the non-inverted condition, but this was only partially born out in the results. That is the sighted group which were allowed to visually perceive the shapes did do better in the non-inverted condition. However, there was no significant difference between non-inverted and inverted conditions when either blind or blindfolded sighted subjects tactually encoded the shapes. It seemed tactual encoding was less susceptible to changes in orientation than visualization. O'Conners suggested that tactual perception uses a different frame of reference, possibly the body or arm movements, than does visual perception which uses the shapes themselves as the frame of reference or focus. It should further be noted that O'Conners found the sighted who used visual perception performed significantly better than either the blind or blindfolded sighted, who used tactual perception as their method of encoding. Not surprisingly this suggests that visualization is superior to tactual processing.

O'Conner's second experiment involved a somewhat different task. In the first experiment form was the salient feature. However, in the second experiment spatial orientation was the salient feature. In the second experiment the experimenter presented subjects with a left or right plastic hand in a variety of conditions. First, there were six orientation conditions: fingers pointed up vertically, fingers pointed down vertically, to the left, to the right, toward the experimenter, and away from the experimenter. Second there were three axis in which the hand rested on: either a vertical axis pointing up or down; or a horizontal plane pointing to the left or right, toward the experimenter or away from the experimenter. This made a total of 24 different presentation conditions. After each presentation subjects were to judge whether the hand was a left or right hand. As in Experiment 1, O'Conners tested early blind, blindfolded sighted and non-blindfolded sighted subjects. The first two groups tactually explored the hands while the latter group used visual perception.

O'Conners found that the blindfolded sighted performed significantly better than the blind on this second experiment. O'Conners interpreted this to mean that the blindfolded sighted were able to take advantage of their visual imagery ability whereas the early blind presumably had no visual imagery from which to profit. O'Conners thus concluded that visual imagery was a salient component in this second experiment.

It should be noted that this finding is quite different from the first experiment where O'Conners suggested that visual imagery was "not" the salient feature based on the finding that blind and blindfolded sighted subjects were found to perform at "similiar" levels. O'Conners suggested that the different results between the two experiments was a result of the different tasks. The first task involving form discrimination and the second task involving spatial orientation. That visual imagery is required on the second and not the first task explains the early blind's relative better performance on the first task but not the second.

On this second experiment O'Conners also found that the sighted and blindfolded sighted were affected by differing orientations of the plastic hand while the blind were not as affected. The differential then was whether a person was sighted or not in determining whether he/she was affected by orientation. However, in the first experiment the affect of orientation was somewhat different. That is, in the first experiment the blindfolded sighted and blind were not affected by changes in inversion while the sighted group was influenced by such changes. This indicates that the method of encoding was the crucial determinate in the first experiment, the blind and the blindfolded sighted using tactual perception and the sighted using visual perception. For now, these different effects across the two experiments are not well understood. These results reflect the basic differences in the two tasks, the first task involving form discrimination and manipulation, the second task involving spatial orientation.

## Mental Rotation

Several studies have examined the early blinds' ability to mentally rotate objects. In particular two studies are of interest, one conducted by Marmor and Zaback (1976) and another conducted by Carpenter and Eisenberg (1978). The primary question was whether mental rotation of objects required visual imagery or not. In order to investigate this question these researchers measured whether the early blind were able to mentally rotate objects or not. They reasoned that if the early blind, who were presumed not to have visual imagery, could indeed mentally rotate objects such a process need not depend on visual imagery.

Marmor measured mental rotation by modification of an earlier task used by Shepard and Metzlar (1971). Marmor presented early blind, late blind and blindfolded sighted subjects with two nonsense shapes, placed next to one another on a hard surface. One of these shapes was always presented in an upright position. The other shape was presented either rotated from upright 0, 30, 60, 120, or 150 degrees. Subjects were to tactually explore these two shapes and discern whether they were the same or different. Presumably, to make such a judgement the rotated figure had to be rotated to the upright position, hence this was a mental rotation task. The time required to make such a judgement was taken as a measure of mental rotation. Reaction time was measured from initial tactual contact of objects until a same/different judgement was made.

One potential problem was that this reaction time included more than just the time required to mentally rotate the non-upright shape to the upright position, the only time interval of interest. For instance, the reaction time interval also measured the time required to tactually explore the objects, forming a conceptualization of each object prior to mental rotation. To avoid this problem Marmor subtracted out the subject's "average" time needed to tactually explore the salient features of the two objects from the total reaction time, within each orientation condition.

Marmor found that for both blind and sighted this adjusted reaction time tended to increase linearly with increasing degrees of rotation of the non-upright object. Marmor interpreted this to mean that the task did actually involve rotation. Also, on the presumption that the early blind have no visual imagery, these results were interpreted as indicating mental rotation does not depend on visual imagery, the early blind being able to perform such a task.

Marmor also found that the early blind were overall slower and had significantly more errors than the late blind or sighted. The late blind and sighted performed at a similiar level. Marmor interpreted these results as suggesting that while visual imagery is not required in mental rotation tasks, the use of visual imagery does make mental rotation tasks easier.

Consistent with these findings, Carpenter also found the early blind were able to mentally rotate images. The technique used by Carpenter was a modification of a procedure developed by Cooper and Shepard (1973). The procedure used by Carpenter consisted of presenting blind and sighted subjects with normal or mirror-image alphabet letters. Two letters were used, "F" and "P". These letters were presented in various orientations from 0 to 300 degrees. Subjects judged whether the presented letter was either a normal or a mirror image letter. Presumably, before subjects could make such judgements they had to rotate the letter to the upright position, hence a mental rotation task. The time required to perform such a task was thought to be a measure of mental rotation.

Carpenter conducted a series of four experiments utilizing the above task. In the first experiment early blind subjects encoded the letters tactually. In experiment two and three, sighted subjects encoded the letter through visual perception and haptic perception, respectively. In experiment four, sighted blindfolded subjects haptically encoded the letters as in experiment three, but with one difference. That is, in experiment four subjects' arm movements during tactual encoding were controlled under two conditions, the "straight" and "bent" arm conditions. In the straight arm condition the arm subjects used to tactually explore the letter was placed perpendicular to his/her frontal plane. In the bent arm condition, this arm was placed at an angle from subject's frontal plane.

The purpose of the arm manipulation was to investigate the frame of reference in haptic rotation. What is interpreted as upright in a haptic rotation task could depend on the position of the arm, the body or even the floor or table. If the frame of reference is the arm, changes in the arm position should produce corresponding changes in how long it takes to rotate an object through haptic encoding. If, however, the frame of reference is the body or floor, etc., changes in the arm position should have no effect on such mental rotation.

In the first experiment, concerning the blind's ability to rotate the letters through haptic encoding, Carpenter found reaction time increased "linearly" as a function of the degree of rotation required. This was interpreted as illustrating the early blind did mentally rotate objects indicating mental rotation can occur without visual imagery under the presumption that early blind have no visual imagery. In experiments two and three, concerning sighted subjects in visual and haptic encoding presentations, a "curvilinear" relation was found between reaction time and the degree of rotation required. This still suggested that the letters were mentally rotated. However, the fact that the relationship was curvilinear and not linear as was found in experiment one involving blind subjects, suggested a small difference in the manner in which the early blind and sighted rotate objects. The curvilinear relationship found with sighted subjects suggested that the sighted did not rotate the letters completely to the upright condition, before making their judgements, whereas the results in Experiment 1 indicated the blind rotated the letters completely to the upright condition. One other interesting finding was that Carpenter found a "lower" reaction time for the blind in the 0 degree orientation condition than for the sighted, indicating the blind are not always "less" able to perform such tasks. Finally, in experiment four Carpenter found a difference between the straight arm and bent arm conditions. This indicated that the position of the arm had an effect on haptic rotation, suggesting that the frame of reference in haptic rotation is the hand itself.

## Cognitive Maps

The term "cognitive map" here refers to some internal representation of either a large environmental stimulus, a college campus, etc., or an internal representation of a smaller environmental scene, a road map, a T-maze, etc. Downs and Stea (1973) have emphasized that such representations need not be visual in nature, but may be functional analogs of the real world. Presumably, the cognitive maps of the early blind are of a functional analog nature, compared with a visual orientation. The question here is how accurate are such internal representations in the early blind.

A study conducted by Casey (1978) investigated the cognitive maps of the blind. The particular maps under investigation were of a familiar school campus. Casey had subjects name a particular building on the school campus, at which time the experimenter would hand the subject a wooden model of the particular building requested. Subjects were to place this wooden model on a flat surface in the relative location where he/she judged the building to be on the actual campus. This continued until all the buildings were placed on the flat surface. Likewise subjects were to place the sidewalks on this flat surface, by placing flexible adhesive strips where subjects judged sidewalks should appear on the campus model.

Two judges evaluated the organizational content of the maps formed by the early blind and sighted using a double blind procedure. Judges consistently ranked the sighted subjects' maps as more organized than the maps formed by the early blind. The blind had difficulty identifying all the buildings on the campus. Also, the blind tended to organize buildings into discrete functional sets, not conceptualizing the campus as a whole. Finally, the blind tended to straighten out sidewalks which were curved, as if the blind were not aware of small curves in the sidewalk.

Cleaves and Royal (1979) have also studied cognitive mapping in the early blind. But the cognitive maps were of a small environmental stimulus rather than a large environment such as a school campus. Specifically, Cleaves and Royal used T-mazes as the environmental stimulus. The alleys of the maze were indentations in a flat wooden surface. There was a designated starting point and goal on each maze. Mazes were either simple, having one curve, or complex, having two curves.

After subjects learned a maze through tactual exploration of the indented alleys, a flat surface was laid across the maze, covering the maze. Subjects' left hand index finger was placed on a certain point on this flat surface.

This point corresponded to the starting point of the covered maze. Using this point as a reference, subjects were to indicate where the turns and goal of the covered maze would be located on this flat surface. Subjects located such points on this flat surface through their imagery of the maze. In at least an analogous sense this image represented a congitive map of a smaller stimulus. What Cleaves found was that the early blind did poorer than the late blind and the late blind performed poorer than the sighted on these tasks. This illustrates again the advantage of visualization prior to blindness on imagery processing.

## Other Studies

The studies covered in this last section also concern the imagery of the blind but for one reason or another do not fit into the above categories. The first study of interest concerns mnemonics in the early blind (Jonides, Kahn, & Rozan, 1975). Jonides had early blind and sighted subjects learn a paired associate list under two conditions. In the first condition subjects were given 20 pairs of words. Subjects were to recall the second word in each pair given the first word as a cue with no instructions as to how to remember these pairs. In the second condition subjects were given the same paired associate task, but were also given instructions as to how to remember each pair. Subjects were told to form an image relating the two words, a mnemonics device. Ten of the 20 pairs of words given in each condition were low imagery words while the other ten pairs were made up of high imagery words.

Jondies found that giving mnemonic instructions improved the performance in both the early blind and sighted in both the low and high imagery words. The high imagery words were overall easier to remember for both groups across the no instruction and mnemonic instruction conditions. The interesting finding is that the early blind were aided by mnemonics. Jonides suggested this indicated mnemonics is effective even without the use of visual imagery, presuming the early blind have no visual imagery. This implies that mnemonics does not work because of some visual imagery association but for some other reason. One suggestion was that mnemonics works because it aids in the establishment of a relationship between phenomena (Bower, 1972).

The next study of importance was conducted by Marmor (1977) and might have been included in the form discrimination section. The task itself seems to involve form discrimination. However, Marmor used a line of logic which makes this study unique. Marmor did not assume the early blind have no visual imagery as is customary. Rather, Marmor sought to investigate whether the early blind do or do not have visual imagery. To do this Marmor modified a visual imagery task used by Weber and Castleman (1970). Marmor divided the alphabet into tall letters, (b,d,f) and short letters (a,c,e). Upon hearing a letter subjects were to judge whether that letter was a tall or short letter. Presumably this task involved visual imagery, requiring the visualization of each letter. Theoretically, the time required to make such judgements is a measure of visual imagery.

What Marmor found was that the early blind took significantly longer to make such judgements compared with the processing time required by sighted subjects. Marmor concluded that this was support for the presumption that the early blind have no visual imagery, that the blinds' deficit on this task was due to them having no visual imagery. However, two problems remain with such a conclusion. First, this explanation does not take into account that the early blind were able to perform the task, irrespective of the time involved. How could the early blind perform this task without some visual imagery? Second, there may be alternative explanations for the early blinds' deficit. One possibility is that the early blind were not as familiar with the alphabet letters used in the task as were the sighted and that the results reflect this disparity. This seems a likely possibility when it is realized that the early blind "rarely" use regular print but rely more on braille. This would indicate the past experience was the differentiating variable.

A study by Rieser, Lockman and Pick (1980) directly addresses this issue concerning the different experiences between the early blind and sighted, examining how such different experiences differentially affect the performance in the early blind and sighted. The particular task used by

Rieser involved spatial imagery. Rieser had early blind and sighted estimate both the straight-line and walking distance between two buildings on a familiar college campus. Rieser found that the early blind and sighted were equally able to estimate the walking distances. However, the sighted were better at estimating the straight-line distance than were the early blind. Rieser suggested this was a function of prior experience, the early blind being more familiar with the walking distance compared to the straight-line distance between objects.

APPENDIX C

Instructions

Instructions for Experiment 1

(Blindfold all subjects and make sure each subject is centered at the table.) In this experiment I am going to lay a variety of what I'll call maps on this table in front of you. Each of these so called maps will consist of a square board with one shape glued on it. The shape on the board will be either a square, a circle, or a triangle. Here is an example map (present middle size example map). During the course of this experiment I will lay several maps, one at a time, here on the table. After I lay a map on the table I want you to form an image of it by touching all of its parts. You are to first imagine the outline of the map as an imaginary square. Then imagine the shape within this square in the position it appeared on the actual map. After you have formed this image I'll take away the map. Then you are to form the image of these maps on the paper placed on the table. After you have formed each image I'll have you do three things, enlarge the size of the image on the paper, shrink the size of the image you have formed on the paper, or keep the image the same size. After you have formed each image I'll hand you a pen. You are to put a dot on the paper where you have imagined the center of the shape on the imaginary map is on the paper.

Each time I ask you to form one of these images of an actual map on the paper I'll show you where on the paper to form this image. I'll show you on the paper where the lower left and lower right hand corner of the image is to be formed on the paper. From these two points you are to form the rest of the image. To understand where you are to form these images on the paper let's go through an example. In this example I'll first show you where to form the image on the paper the same size as the map actually was. Second, I'll show you how to enlarge this image on the paper. Third, I'll show you how to shrink this image on the paper much smaller than the actual map.

So for our example let me lay the same map you felt earlier on the table so you can explore it again. Remember while you explore the map I'd like you to again form an image of the map. This image should consist of a square that represents the sides of the map with the shape within this square. (Lay out the map and let subject explore, then take it away.)

Now in this example let me show you where to form this image of the map on the paper. You are to form this image in a particular spot on the paper. (Place index fingers on example size reference points.) Where I've placed your left hand index finger represents the lower left hand corner of the image. Likewise where I've placed your right hand index finger represents the lower right hand corner of the image. From these two points you are to form the rest of the image. Imagine a square which represents the edges of the image using these corners where your index fingers are as the lower corners of the square. Then imagine the shape within this square. The points where I've placed your index fingers are the exact places on the table where the lower corners of the actual map were placed on the table. After you have formed this image I'll give you a pen and let you place a dot where the center of the shape is located in your image. Tell me when you have your image formed. (Wait until the image is formed.) Here is the pen (put in dominant hand.) Let me place the pen point where your finger was. Be careful to go directly from this point to where the shape is without touching the paper or your other hand. Place your dot when you are ready.

Now let me show you how to enlarge and shrink this image. To show you where to form the enlarged or shrunken image on the paper I need to show you an actual enlarged and shrunken map of the map you've just explored (lay out maps one on top of another). These are the enlarged and shrunken maps (point them out). Why don't you explore how I've placed these maps. Note that the center of the small map is also the center of the other two maps. The sides of the maps expand out from this center. Also notice the corners of the map go out at a 45 degree angle. For instance, here are the two lower corners of the middle size map. The corners of the map go out like this at a 45 degree angle. (Place index finger on middle size map and go out.) It is the same as you go from the middle size map to the shrunken map. (Place index finger in the middle size map and go in). What I want you to do is form an image of these enlarged and shrunken maps on the paper. I'll first have you form the image of the middle size map on the paper as you've already done. Then to form an enlarged map I'll move your fingers out at a 45 degree angle as I just did. As I do this you are to enlarge your image outward. To form a shrunken image I'll have you form the middle size image on the paper using your index fingers as the lower corners of the image. Then I'll move your index fingers in toward the center at a 45 degree angle. As I do this you are to shrink your image. The amount you are to enlarge or shrink your image is determined by how far I move your index fingers in or out. After you have formed these images I'll have you place a dot on the paper where the shape within the enlarged or shrunken image should be on the paper.

So let's practice enlarging and shrinking your image as I've just described. Let's first enlarge the practice map we've been using. Do you remember the map? (If not, lay it out.) To enlarge this map you need to form the image of the map on the paper then enlarge that image. Let me place your index fingers on the paper as I did earlier (place them). Now form the image on the paper, tell me when you have it formed. (Wait.) Let's now enlarge the image, if you have any problems let me know. (Slowly move out index fingers and wait, if subject has difficulty try it again, until subject has the enlarged image.) Now I'd like you to place a dot where the shape of this enlarged image is on the paper. Here is your pen, remember to go directly to where you think the center of the shape is without touching the paper. (Give subject the pen and return fingers to middle size reference point.) Now let's shrink the image. (Have subject imagine middle size image and shrink and reproduce.)

Now that you have imagined a map and enlarged and shrunk an image of the map, I have some more maps for you to feel and form images of. I'll show you where to form these images on the paper by placing your fingers where the lower left and right corners of the image should be as we did in the example. After you have formed each image I'll ask you to either enlarge, shrink or hold the image the same size on the paper. When I ask you to shrink your image I'll move your fingers in. When I ask you to enlarge your image I'll move your fingers out on the paper. I will not show you an actual enlarged or shrunken map. You can judge the amount of enlarging or shrinking of a map by how far I move your fingers in or out. After you form each image I will have you place a dot where you judge the center of the shape to be on the paper. These maps will all have one shape on them but in different positions. This shape will either be a circle, square or a triangle. These maps may be large or small. Do you have any questions? Ready? (See record form for the order of maps to use.)

## Instructions for Experiment 2

Now I have some more maps that I want you to imagine on the paper as you've just done. I'll have you enlarge and shrink these maps also. The only difference is each of these maps has three shapes on it, a square, a circle, and a triangle, compared to having only one shape on a map as the maps you've just imagined. Let's go through the example first. You'll need to remember where each shape on the map is, so take your time. (Go through example.) Now let's go through the actual trials. (Have subjects imagine a map, form an image, then enlarge, shrink or neither enlarge or shrink it. Then reproduce each image. Do this until a map has been reproduced in all three conditions, then present the next map. See record form for order of presentation and reproduction.)

APPENDIX D

PRE-TEST DISCLOSURE, POST-TEST QUESTIONNAIRE

AND POST-TEST DEBRIEFING

## Pre-Test Disclosure

Before we begin there are certain things I feel obligated to discuss with you. First, I want you to understand your participation is completely voluntary. You may withdraw from the study at any time. Second, your performance in this study is anonymous (explain that his/her name is never used, that a code number is used). Third, after the study is over, I'll explain its purpose further so you won't leave wondering what it is all about.

## Post-Test Questionaire

On the tasks you just did you could have used visual/spatial imagery, tactual imagery, kinesthetic imagery or some other kind of imagery. These various types of imagery are all different. Visual/spatial imagery is where you picture objects and their relationship to one another in your imagination. Tatual imagery is where you imagine how something feels. Kinesthetic imagery is where you imagine your arms or other body parts moving. Verbal imagery is where you form an image through the aid of talking to your self, saying for example this object is two inches from another or on top of another object, etc.

Do you understand each of these types of imagery? (If not, explain.) What I'd like you to do is tell me what kind of imagery you used on the task you just performed. For instance, let's take the first task you performed. If you'll remember this task involved enlarging and shrinking an image. This image had only one object in it. What percentage of the time did you use visual/spatial, tactual, kinesthetic or verbal imagery in the task? (Record answer on record form.)

Now I want to ask you the same question for the second task. This task also involved enlarging and shrinking of images. These images had not one object as in the first task, but three. Tell me what percentage of which type of imagery did you use? (Write answer on record form.)

## Post-Test Debriefing

I'd like to tell you why this experiment is being conducted. These tasks will be performed by twelve blind and twelve sighted people. This study hopes to compare the results between blind and sighted. All the blind people are blind at or around birth. The literature indicates that such blind people have no visual imagery. The question put forth in this study is how such a deficit effects a blind person's performance on the above tasks compared to a sighted subject. These tasks do seem to involve at least some visual imagery. As such, according to the literature the blind should have difficulty performing such tasks. However, if the blind perform such tasks as well as sighted, it means that they may have at least some limited visual imagery. These tasks are relevent to your everyday life. For instance, to form an image of a college campus you must shrink the buildings, etc. down to a manageable image size as you did in the first two tasks. Any comments or questions?

# APPENDIX E

## Tables

Table I

Experiment 1. Straight-line Error.

Analysis of Variance Summary Table.

| Source | df | SS | F | p> F |
|---|---|---|---|---|
| <u>Between-Subjects</u> | | | | |
| Group | 1 | 1736.62 | 13.47 | .0018 |
| Error 1<br>Subj(Group) | 18 | 2320.65 | | |
| <u>Within-Subjects</u> | | | | |
| Image Manipulations(I.M.) | 2 | 5591.88 | 215.8 | .0001 |
| Group X I.M. | 2 | 570.74 | 22.03 | .0001 |
| Error 2<br>I.M. X Subj(Group) | 36 | 466.29 | | |
| Map Size(Size) | 1 | 2105.35 | 84.22 | .0001 |
| Group X Size | 1 | 185.64 | 7.43 | .0139 |
| Error 3<br>Size X Subj(Group) | 18 | 449.96 | | |
| I.M. X Size | 2 | 225.72 | 22.73 | .0001 |
| Group X I.M. X Size | 2 | 40.41 | 4.97 | .0255 |
| Error 4<br>I.M. X Size X Subj(group) | 36 | 178.76 | | |

Table II

Experiment 1. Straight-line Error(cm).

Means and Standard Deviations.

| | Blind | | Sighted | |
|---|---|---|---|---|
| | M | SD | M | SD |
| **Small Maps** | | | | |
| Image Manipulation | | | | |
| Shrink | 2.51 | 1.33 | 1.72 | .87 |
| No Shrink/Enlarge | 4.78 | 2.41 | 3.35 | 1.66 |
| Enlarge | 9.53 | 4.63 | 5.49 | 2.69 |
| **Large Maps** | | | | |
| Image Manipulation | | | | |
| Shrink | 5.06 | 2.83 | 3.55 | 1.96 |
| No Shrink/Enlarge | 9.25 | 4.72 | 5.27 | 3.09 |
| Enlarge | 15.84 | 7.67 | 8.96 | 5.43 |

Table III

Experiment 1. X- Coordinate Error.

Analysis of Variance Summary Table.

| Source | df | SS | F | p> F |
|---|---|---|---|---|
| <u>Between-Subjects</u> | | | | |
| Group | 1 | 3.30 | .08 | .7747 |
| Error 1<br>Subj(Group) | 18 | 705.97 | | |
| <u>Within-Subjects</u> | | | | |
| Image Manipultion(I.M.) | 2 | 121.16 | 7.3 | .002 |
| Group X I.M. | 2 | 40.59 | 2.45 | .101 |
| Error 2<br>I.M. X Subj(Group) | 36 | 298.88 | | |
| Map Size(Size) | 1 | 89.18 | 1.56 | .2282 |
| Group X Size | 1 | 3.33 | .06 | .8121 |
| Error 3<br>Size X Subj(Group) | 18 | 1031.46 | | |
| I.M. X Size | 2 | 234.46 | 7.81 | .0015 |
| Group X I.M. X Size | 2 | 5.35 | .18 | .8374 |
| Error 4<br>I.M. X Size X Subj(Group) | 36 | 540.20 | | |

Table IV

Experiment 1. X- Coordinate Error(cm).

Means and Standard Deviations.

| | Blind | | Sighted | |
|---|---|---|---|---|
| | M | SD | M | SD |
| Small Maps | | | | |
| Image Manipulation | | | | |
| Shrink | .34 | 1.11 | .34 | 1.10 |
| No Shrink/Enlarge | .88 | 2.37 | .89 | 1.76 |
| Enlarge | 1.46 | 4.47 | .63 | 2.41 |
| Large Maps | | | | |
| Image Manipulation | | | | |
| Shrink | .15 | 2.46 | .90 | 1.69 |
| No Shrink/Enlarge | .92 | 3.38 | .89 | 2.47 |
| Enlarge | -0.90 | 6.84 | -1.62 | 6.28 |

Table V

Experiment 1. Y- Coordinate Error.

Analysis of Variance Summary Table.

| Source | df | SS | F | p > F |
|---|---|---|---|---|
| Between-Subjects | | | | |
| Group | 1 | 1735.07 | 13.48 | .0017 |
| Error 1 Subj(Group) | 18 | 2317.66 | | |
| Within-Subjects | | | | |
| Image Manipulation(I.M.) | 2 | 4311.27 | 151.14 | .0001 |
| Group X I.M. | 2 | 447.13 | 15.67 | .0001 |
| Error 2 I.M. X Subj(Group) | 36 | 513.46 | | |
| Map Size(Size) | 1 | 1846.72 | 65.99 | .0001 |
| Group X Size | 1 | 202.90 | 7.25 | .0149 |
| Error 3 Size X Subj(Group) | 18 | 503.69 | | |
| I.M. X Size | 2 | 148.97 | 16.80 | .0001 |
| Group X I.M. X Size | 2 | 30.31 | 3.42 | .0437 |
| Error 4 I.M. X Size X Subj(Group) | 36 | 159.61 | | |

Table VI

Experiment 1. Y-Coordinate Error(cm).

Means and Standard Deviations.

| | Blind | | Sighted | |
|---|---|---|---|---|
| | M | SD | M | Sd |
| Small Maps | | | | |
| Image Manipulation | | | | |
| Shrink | -2.4 | 1.47 | -1.17 | 1.17 |
| No Shrink/Enlarge | -4.04 | 2.38 | -2.60 | 2.03 |
| Enlarge | -8.34 | 4.64 | -4.52 | 3.35 |
| Large Maps | | | | |
| Image Manipulation | | | | |
| Shrink | -4.61 | 2.72 | -2.79 | 2.07 |
| No Shrink/Enlarge | -8.59 | 4.72 | -4.43 | 3.40 |
| Enlarge | -14.01 | 8.36 | -7.50 | 6.14 |

Table VII

Experiment 1. The Enlarging Process.

Analysis of Variance Summary Table.

| Source | df | SS | F | p > F |
|---|---|---|---|---|
| Dependent Variable(Straight-Line Error) | | | | |
| Between-Subjects | | | | |
| Group | 1 | 964.00 | 15.87 | .0009 |
| Error 1 Subj(Group) | 18 | 1093.11 | | |
| Within-Subjects | | | | |
| Control(Con) | 1 | 3.80 | 0.61 | .4445 |
| Group X Control | 1 | 0.054 | 0.01 | .9268 |
| Error 2 Con X Subj(Group) | 18 | 111.90 | | |
| Dependent Variable (X-coor.) | | | | |
| Between-Subjects | | | | |
| Group | 1 | 10.92 | .063 | .4393 |
| Error 1 Subj(Group) | 18 | 314.37 | | |
| Within-Subjects | | | | |
| Control(Con) | 1 | 1.26 | 0.04 | .8452 |
| Control X Group | 1 | 9.60 | 0.30 | .5915 |
| Error 2 Con X Subj(Group) | 18 | 5789.92 | | |

Table VII (Continued)
Dependent Variable(Y-coor.)

| | | | | |
|---|---|---|---|---|
| Between-Subjects | | | | |
| Group | 1 | 958.00 | 17.37 | .0006 |
| Error 1<br>Subj(Group) | 18 | 992.99 | | |
| Within-Subjects | | | | |
| Control(Con) | 1 | 0.40 | 0.05 | .8322 |
| Control X Group | 1 | 1.71 | 0.19 | .6645 |
| Error 2<br>Con X Subj(Group) | 18 | 158.98 | | |

Table VIII

Experiment 1. The Shrinking Process.

Analysis of Variance Summary Table.

| Source | df | SS | F | p > F |
|---|---|---|---|---|
| **Dependent Variable(Straight-Line Error)** | | | | |
| Between-Subjects | | | | |
| Group | 1 | 129.21 | 4.99 | .0385 |
| Error 1<br>Subj(Group) | 18 | 466.40 | | |
| Within-Subjects | | | | |
| Control(Con) | 1 | 3.29 | 0.84 | .3705 |
| Group X Control | 1 | 0.08 | 0.02 | .8847 |
| Error 2<br>Con X Subj(Group) | 18 | 70.19 | | |
| **Dependent Variable(X-coor.)** | | | | |
| Between-Subjects | | | | |
| Group | 1 | 8.74 | 0.62 | .4419 |
| Error 1<br>Subj(Group) | 18 | 254.45 | | |
| Within-Subjects | | | | |
| Control(Con) | 1 | 7.77 | 1.23 | .2811 |
| Group X Control | 1 | 7.92 | 1.26 | .2768 |
| Error 2<br>Con X Subj(Group) | 18 | 113.34 | | |

Table VIII (Continued)
Dependent Variable(Y-coor.)

| | | | | |
|---|---|---|---|---|
| Between-Subjects | | | | |
| Group | 1 | 159.90 | 6.38 | .0211 |
| Error 1<br>Subj(Group) | 18 | 451.02 | | |
| Within-Subjects | | | | |
| Control(Con) | 1 | 8.62 | 2.22 | .1536 |
| Group X Control | 1 | 2.22 | 0.57 | .4926 |
| Error 2<br>Con X Subj(Group) | 18 | 69.94 | | |

Table IX

Experiment 1. Introspective Data.

Analysis of Variance Summary Table.

| Source | df | SS | F | p > F |
|---|---|---|---|---|
| Depdendent Variable(Visual/Spatial Imagery) | | | | |
| Between Groups | 1 | 9.80 | 0.01 | .9238 |
| Error 1 Subj(Group) | 18 | 18744.00 | | |
| Dependent Variable(Verbal Imagery) | | | | |
| Between Groups | 1 | 2486.45 | 8.59 | .0089 |
| Error 1 Subj(Group) | 18 | 5210.10 | | |
| Dependent Variable(Tactual Imagery) | | | | |
| Between Groups | 1 | 911.25 | 2.33 | .1446 |
| Error 1 Subj(Group) | 18 | 7051.70 | | |
| Dependent Variable(Kinesthetic Imagery) | | | | |
| Between Groups | 1 | 8.45 | 0.01 | .9246 |
| Error 1 Subj(Group) | 18 | 16531.30 | | |

Table X

Experiment 1. Introspective Data (Percentages).

Means and Standard Deviations.

| | Blind | | Sighted | |
|---|---|---|---|---|
| | M | SD | M | SD |
| Mode of Imagery | | | | |
| Visual/Spatial | 48.40 | 36.34 | 40.80 | 27.60 |
| Verbal | 3.50 | 8.18 | 25.80 | 22.62 |
| Tactual | 20.70 | 27.03 | 7.20 | 7.26 |
| Kinesthetic | 27.40 | 37.11 | 26.10 | 27.17 |
| Other | 0.00 | 0.00 | 0.00 | 0.00 |

Table XI

Experiment 2. Straight-Line Error.

Analysis of Variance Summary Table.

| Source | df | SS | F | p > F |
|---|---|---|---|---|
| <u>Between-Subjects</u> | | | | |
| Group | 1 | 1378.90 | 12.40 | .0024 |
| Error 1<br>Subj(Group) | 18 | 2001.04 | | |
| <u>Within-Subjects</u> | | | | |
| Image Manipulation(I.M.) | 2 | 5535.58 | 162.32 | .0001 |
| Group X I.M. | 2 | 398.82 | 11.70 | .0001 |
| Error 2<br>I.M. X Subj(Group) | 36 | 613.83 | | |
| Map Size(Size) | 1 | 2498.37 | 78.41 | .0001 |
| Group X Size | 1 | 150.88 | 4.74 | .0430 |
| Error 3<br>Size X Subj(Group) | 18 | 572.85 | | |
| I.M. X Size | 2 | 604.75 | 26.59 | .0001 |
| Group X I.M. X Size | 2 | 61.61 | 2.71 | .0802 |
| Error 4<br>I.M. X Size X Subj(group) | 36 | 409.41 | | |

Table XII

Experiment 2. Straight-Line Error(cm).

Means and Standard Deviations.

| | Blind | | Sighted | |
|---|---|---|---|---|
| | M | SD | M | SD |
| **Small Maps** | | | | |
| Image Manipulation | | | | |
| Shrink | 2.45 | 1.18 | 1.14 | 0.73 |
| No Shrink/Enlarge | 4.02 | 2.29 | 2.98 | 1.83 |
| Enlarge | 7.92 | 3.70 | 4.71 | 2.70 |
| **Large Maps** | | | | |
| Image Mainpulation | | | | |
| Shrink | 4.64 | 2.70 | 2.89 | 1.50 |
| No Shrink/Enlarge | 7.84 | 4.16 | 5.06 | 3.66 |
| Enlarge | 15.83 | 7.93 | 9.31 | 6.22 |

Table XIII

Experiment 2. X-Coordinate Error.

Analysis of Variance Summary Table.

| Source | df | SS | F | p > F |
|---|---|---|---|---|
| <u>Between-Subjects</u> | | | | |
| Group | 1 | 15.28 | 0.12 | .7288 |
| Error 1<br>Subj(Group) | 18 | 2218.89 | | |
| <u>Within-Subjects</u> | | | | |
| Image Manipulation(I.M.) | 2 | 134.82 | 3.19 | .0530 |
| Group X I.M. | 2 | 8.48 | 0.20 | .8189 |
| Error 2<br>I.M. X Subj(Group) | 36 | 760.33 | | |
| Map Size(Size) | 1 | 0.17 | 0.01 | .9338 |
| Group X Size | 1 | 4.37 | 0.18 | .8189 |
| Error 3<br>Size X Subj(Group) | 18 | 449.23 | | |
| I.M. X Size | 2 | 28.77 | 1.76 | .1872 |
| Group X I.M. X Size | 2 | 23.80 | 1.45 | .2472 |
| Error 4<br>I.M. X Size X Subj(Group) | 36 | 294.86 | | |

Table XIV

Experiment 2. X-Coordinate Error(cm).

Means and Standard Deviations.

| | Blind | | Sighted | |
|---|---|---|---|---|
| | M | SD | M | SD |
| Small Maps | | | | |
| Image Manipulation | | | | |
| Shrink | 0.33 | 1.55 | 0.25 | 0.89 |
| No Shrink/Enlarge | 7.68 | 2.48 | 0.52 | 1.61 |
| Enlarge | 0.54 | 3.83 | -0.55 | 2.62 |
| Large Maps | | | | |
| Image Manipulation | | | | |
| Shrink | .51 | 2.27 | 0.63 | 1.45 |
| No Shrink/Enlarge | 1.16 | 3.95 | 0.49 | 2.61 |
| Enlarge | -0.68 | 7.63 | -0.52 | 4.63 |

Table XV

Experiment 2. Y- Coordinate Error.

Analysis of Variance Summary Table.

| Source | df | SS | F | p > F |
|---|---|---|---|---|
| Beteen-Subjects | | | | |
| Group | 1 | 1232.71 | 10.40 | .0047 |
| Error 1 Subj(Group) | 18 | 2133.82 | | |
| Within-Subjects | | | | |
| Image Manipulation(I.M.) | 2 | 4303.42 | 123.25 | .0001 |
| Group X I.M. | 2 | 408.77 | 11.71 | .0001 |
| Error 2 I.M. X Subj(Group) | 36 | 628.48 | | |
| Map Size(Size) | 1 | 2130.39 | 70.11 | .0001 |
| Group X Size | 1 | 166.75 | 5.49 | .0301 |
| Error 3 Size X Subj(Group) | 18 | 546.98 | | |
| I.M. X Size | 2 | 390.78 | 13.89 | .0001 |
| Group X I.M. X Size | 2 | 39.54 | 1.41 | .2583 |
| Error 4 I.M. X Size X Subj(Group) | 36 | 506.36 | | |

Table XVI

Experiment 2. Y-Coordinate Error(cm).

Means and Standard Deviations.

| | Blind | | Sighted | |
|---|---|---|---|---|
| | M | SD | M | SD |
| **Small Maps** | | | | |
| Image Manipulation | | | | |
| Shrink | -1.41 | 1.66 | -0.41 | 0.95 |
| No Shrink/Enlarge | -2.96 | 2.34 | -2.18 | 2.11 |
| Enlarge | -6.69 | 4.12 | -3.50 | 3.19 |
| **Large Map** | | | | |
| Image Manipulation | | | | |
| Shrink | -3.91 | 2.72 | -2.10 | 1.80 |
| No Shring/Enlarge | -6.62 | 4.12 | -3.99 | 3.14 |
| Enlarge | -13.74 | 8.31 | -7.44 | 7.08 |

Table XVII

Experiment 2. The Enlarging Process

Analysis of Variance Summary Table

| Source | df | SS | F | p > F |
|---|---|---|---|---|
| Dependent Variable(Straight-Line Error) | | | | |
| Between-Subjects | | | | |
| Group | 1 | 538.50 | 13.57 | .0017 |
| Error 1 Subj(Group) | 18 | 714.41 | | |
| Within-Subjects | | | | |
| Control(Con) | 1 | 1.10 | 0.10 | .7546 |
| Group X Control | 1 | 2.66 | 0.24 | .6283 |
| Error 2 Con X Subj(Group) | 18 | 197.85 | | |
| Dependent Variable(X-Coor.) | | | | |
| Between-Subjects | | | | |
| Group | 1 | 47.17 | 0.86 | .3660 |
| Error 1 Subj(Group) | 18 | 987.19 | | |
| Within-Subjects | | | | |
| Control(Con) | 1 | 42.33 | 2.84 | .1094 |
| Group X Control | 1 | 2.68 | 0.18 | .6763 |
| Error 2 Con X Subj(Group) | 18 | 268.56 | | |

Table XVII (continued)
Dependent Variable(Y-Coor.)

| | | | | |
|---|---|---|---|---|
| Between-Subjects | | | | |
| Group | 1 | 508.95 | 9.82 | .0057 |
| Error 1 Subj(Group) | 18 | 932.85 | | |
| Within-Subjects | | | | |
| Control(Con) | 1 | 2.58 | 0.29 | .5947 |
| Group X Control | 1 | 4.56 | 0.52 | .4807 |
| Error 2 Con X Subj(Group) | 18 | 158.49 | | |

Table XVIII

Experiment 2. The Shrinking Process.

Analysis of Variance Summary Table.

| Source | df | SS | F | p > F |
|---|---|---|---|---|
| Dependent Variable(Straight-Line Error) | | | | |
| Between-Subjects | | | | |
| Group | 1 | 117.32 | 5.67 | .0284 |
| Error 1 Subj(Group) | 18 | 372.13 | | |
| Within-Subjects | | | | |
| Control(Con) | 1 | 4.05 | 1.78 | .1987 |
| Group X Control | 1 | 7.42 | 3.26 | .0878 |
| Error 2 Con X Subj(Group) | 18 | 40.99 | | |
| Dependent Variable(X-Coor.) | | | | |
| Between-Subjects | | | | |
| Group | 1 | 0.03 | 0.00 | .9656 |
| Error 1 Subj(Group) | 18 | 330.40 | | |
| Within-Subjects | | | | |
| Control(Con) | 1 | 0.07 | 0.02 | .8996 |
| Group X Control | 1 | 1.10 | 0.26 | .6170 |
| Error 2 Con X Subj(Group) | 18 | 76.94 | | |

Table XVIII (continued)
Dependent Variable (Y-Coor.)

| | | | | |
|---|---|---|---|---|
| Between-Subjects | | | | |
| Group | 1 | 100.36 | 5.05 | .0374 |
| Error 1<br>Subj(Group) | 18 | 357.87 | | |
| Within-Subjects | | | | |
| Control(Con) | 1 | 11.44 | 5.87 | .0262 |
| Group X Control | 1 | 15.91 | 8.16 | .0105 |
| Error 2<br>Con X Subj(Group) | 18 | 35.10 | | |

Table XIX

Experiment 2. Introspective Data.

Analysis of Variance Summary Table.

| Source | df | SS | F | p > F |
|---|---|---|---|---|
| Dependent Variable(Visual/Spatial Imagery) | | | | |
| Between Groups | 1 | 312.05 | .33 | .5731 |
| Error 1 Subj(Group) | 18 | 17050.90 | | |
| Dependent Variable(Verbal Imagery) | | | | |
| Between Groups | 1 | 1280.00 | 4.59 | .0460 |
| Error 1 Subj(Group) | 18 | 5015.00 | | |
| Dependent Variable(Tactual Imagery) | | | | |
| Between Groups | 1 | 490.05 | 1.51 | .2342 |
| Error 1 Subj(Group) | 18 | 5822.90 | | |
| Dependent Variable(Kinesthetic Imagery) | | | | |
| Between Groups | 1 | 16.20 | .03 | .8592 |
| Error 1 Subj(Group) | 18 | 9000.60 | | |

Table XX

Experiment 2. Introspective Data (Percentages).

Means and Standard Deviations.

| | Blind | | Sighted | |
|---|---|---|---|---|
| | M | SD | M | SD |
| Mode of Imagery | | | | |
| Visual/Spatial | 51.90 | 40.55 | 44.00 | 15.81 |
| Verbal | 7.50 | 16.87 | 23.50 | 16.50 |
| Tactual | 20.90 | 22.56 | 11.00 | 11.73 |
| Kinesthetic | 19.70 | 27.17 | 21.50 | 16.16 |
| Other | 0.00 | 0.00 | 0.00 | 0.00 |

Table XXI

Experiment 1 and 2 Compared.

Analysis of Variance Summary Table.

| Source | df | SS | F | p > F |
|---|---|---|---|---|
| **Dependent Variable(Straight-Line Error)** | | | | |
| Between-Subjects | | | | |
| Group | 1 | 3105.23 | 129.11 | .0001 |
| Error 1 Subj(Group) | 18 | 3996.55 | | |
| Within-Subjects | | | | |
| Experiment 1 or 2(Exp) | 1 | 107.69 | 5.96 | .0252 |
| Group X Exp | 1 | 10.30 | 0.57 | .4599 |
| Error 2 Exp X Subj(Group) | 18 | 325.14 | | |
| **Dependent Variable(X-Coor.)** | | | | |
| Between-Subjects | | | | |
| Group | 1 | 16.90 | 1.53 | .2170 |
| Error 1 Subj(Group) | 18 | 1940.08 | | |
| Within-Subjects | | | | |
| Exp | 1 | 5.81 | 0.11 | .7482 |
| Exp X Group | 1 | 2.18 | 0.04 | .8438 |
| Error 2 Exp X Subj(Group) | 18 | 984.79 | | |

Table XXI (continued)
Dependent Variable(Y-Coor.)

| | | | | |
|---|---|---|---|---|
| Between-Subjects | | | | |
| Group | 1 | 2946.37 | 124.40 | .0001 |
| Error 1<br>Subj(Group) | 18 | 4065.29 | | |
| Within-Subjects | | | | |
| Exp | 1 | 233.93 | 10.90 | .0040 |
| Exp X Group | 1 | 21.41 | 1.00 | .3310 |
| Error 2<br>Exp X Subj(Group) | 18 | 386.19 | | |

Table XXII

Experiment 1 and 2 Compared Error(cm).

Means and Standard Deviations.

| | Blind | | Sighted | |
|---|---|---|---|---|
| | M | SD | M | SD |
| Experiment 1 | | | | |
| Straight-Line Error | 7.83 | 6.20 | 4.73 | 3.74 |
| X-Coordinate Error | 0.47 | 3.94 | 0.34 | 3.23 |
| Y-Coordinate Error | -6.94 | 6.05 | -3.83 | 3.94 |
| Experiment 2 | | | | |
| Straight-Line Error | 7.12 | 6.07 | 4.35 | 4.04 |
| X-Coordinate Error | 0.42 | 4.13 | 0.13 | 2.63 |
| Y-Coordinate Error | -5.89 | 5.95 | -3.27 | 4.21 |

VITA

Charles Edward Smith, III

Candidate for the Degree of

Doctor of Philosophy

THESIS: SIZE-SCALING OF IMAGES IN THE BLIND AND SIGHTED

Major Field: Psychology

Biographical:

Personal Data: Born in Oklahoma City, Oklahoma April 4, 1955.

Education: Graduated from high school, Oklahoma City, Oklahoma, in June, 1972; received Bachelor of Arts degree with a minor in Sociology from Oklahoma University in 1978; received Master of Science degree at Oklahoma State University in May, 1982; completed requirements for the Doctor of Philosophy Degree at Oklahoma State University in July, 1984.

Professional Experience: Worked as a crisis counselor at a local crisis center, 1975-1978; practicum student at the Psychological Services Center in Stillwater, Oklahoma, 1979-1981; practicum student on the Mental Health Unit of the Stillwater Medical Center, 1981-1982; National Institute of Mental Health Traineeship recipient, 1979-1982; practicum student at Central Oklahoma Juvenile Treatment Center in Tecumseh, Oklahoma, 1982; practicum student at Rader Diagnostic and Treatment Center in Sand Spring, Oklahoma, 1983; intern at Northern Nebraska Regional and Comprehensive Mental Health Centers Consortium in Norfolk, Nebraska, 1983-1984.